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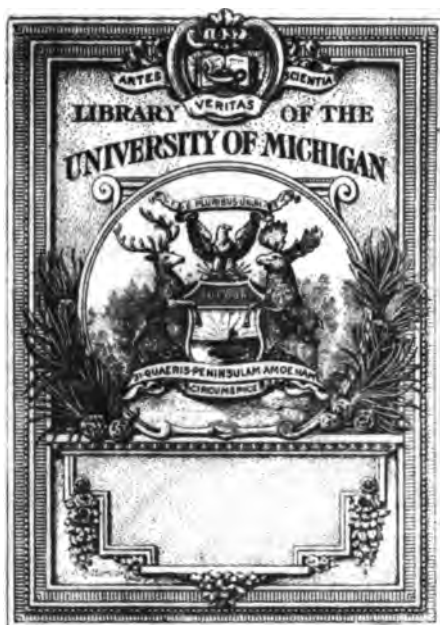
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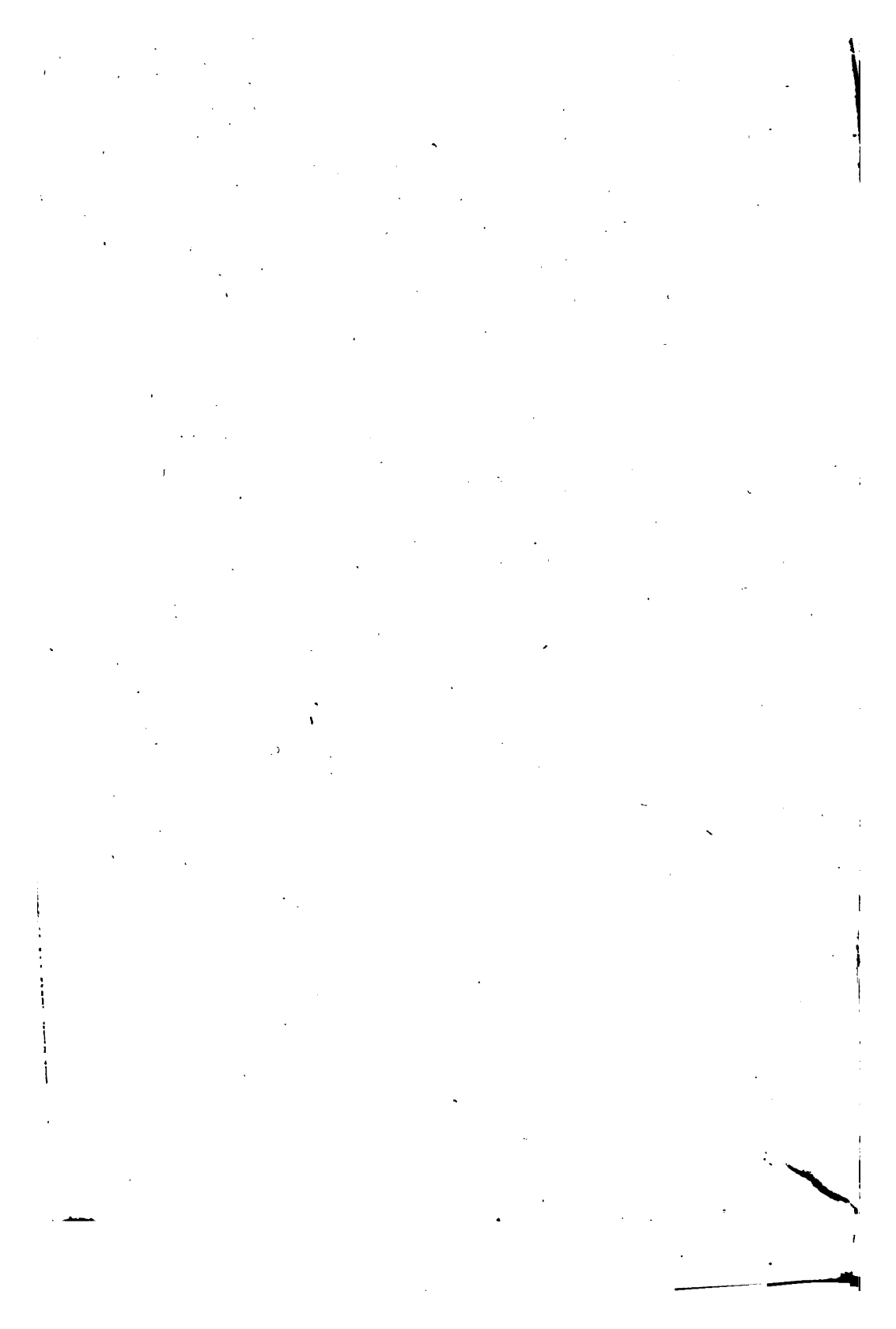
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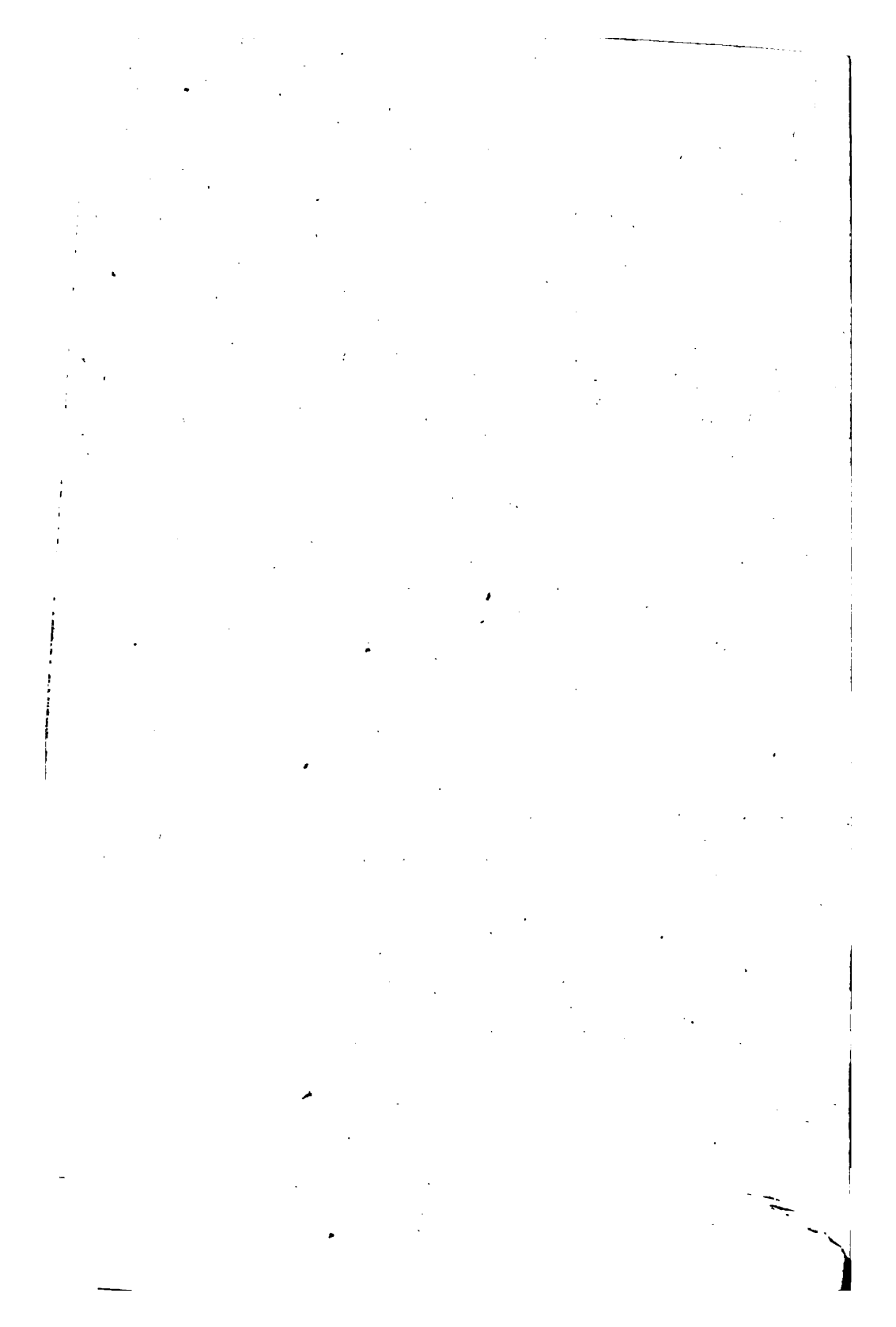




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## **BULLETIN NO. 50**

FEBRUARY 1904

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**New Mexico College of Agriculture and Mechanic Arts**

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**AGRICULTURAL EXPERIMENT STATION**

**MESILLA PARK, N. M.**

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# **STEER AND LAMB FEEDING**

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BY

**J. J. VERNON**

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SANTA FE, N. M.:  
NEW MEXICAN PRINTING COMPANY,  
1904.

# NEW MEXICO AGRICULTURAL EXPERIMENT STATION

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The Bulletins of this Station will be mailed free to Citizens of New Mexico  
who are interested in the work done here, and to others  
as far as the editions printed will allow

## SUMMARY AND CONCLUSIONS

1. Present range methods are wasteful. The grass over large areas is destroyed by close cropping and much tramping. Over-stocking is universal and not likely to be corrected under the present system of handling free public range.

2. It is believed that the price of range stock would be higher and the revenue from range areas would be greater by the introduction of a leasing system or other method whereby a given range area could be controlled for a definite period; by the infusion of better blood into the stock upon the ranges; by carrying two or more kinds of stock, such as cattle, horses and goats, under one management; and by the feeding of large numbers of range grown stock upon the valley farms.

3. The results of these experiments indicate that feeding steers and lambs for the local markets will prove remunerative so long as dealers will pay the same price for the home fed product that they must pay for the imported article of equal quality.

4. Beef and mutton, of a quality suitable for the local market demands, can be produced by feeding alfalfa hay alone. In these tests the addition of grain, though rather high in price, showed the following advantages over feeding alfalfa hay alone: the return per ton for the alfalfa hay consumed was greater, more rapid gains were made, the feeding period was shorter and a much better product was secured.

5. The lambs in these experiments gave a greater return per ton for the alfalfa hay fed than did the steers.

6. About one hundred days for lambs and five or six months for steers, is a sufficient time in which to fit them for the local markets, when fed on alfalfa hay alone. It will require less time when grain is fed with the alfalfa hay.

7. Frequent weighing, because of the unavoidable excitement, is probably not conducive to rapid gains with range grown steers.

### INTRODUCTION

The experiments in feeding cattle and sheep, the results of which are recorded in the following pages, were conducted during the winters of 1901-2 and 1902-3. These experiments are the first of their character that have been conducted at this Station. However, considerable feeding has been done in some parts of the Territory, but so far as known, no records have been kept and information as to the results cannot be obtained.

There has been some demand in the past for information on feeding in New Mexico, and it is believed that the need for such information will be much greater in the future. Upon the completion of storage reservoirs and the development of irrigation systems, which will result in the reclamation of immense arid areas, the feeding industry will command much attention among farmers. There is little information available to the New Mexico farmer and ranchman upon feeding, and therefore, it is thought desirable to publish the data thus far secured upon this subject. The results obtained are suggestive of the possibilities,—the conclusions, however, are only tentative, there not having been a sufficient number of trials from which to draw them.

### PRICES AND RANGE CONDITIONS

Uneasiness is felt among ranchmen in various quarters in regard to prices. Aside from the influences that cause the fluctuation from year to year of the general market, probably, the factor that operates most strongly in controlling prices, is the condition of the ranges, which, in a great measure, determines the quality of the product. The condition of a range in any case depends upon the local rainfall and the number of animals it is made to carry. Over-stocking is almost a universal practise. Under the conditions that prevail generally over the range areas of the Territory, stock must travel long distances between grass and water. This makes necessary a great amount of extra work, and therefore, a large portion of the food is consumed in work that



otherwise might have gone to the production of flesh and bone, and to the making of an animal of much better quality. Over-stocking results in a smaller carcass and a poorer feeder, and so, a comparatively lower price must be accepted.

### REMEDIES

There are several things that would assist in maintaining good prices for range grown stock if they could be made effective:

First. Individual ownership or individual control of range areas, probably, would be the quickest and most effective means that could be employed to this end. The present range methods are wasteful in the extreme in as much as the grass on large areas is practically destroyed by over-stocking. So long as free range exists, just so long will our ranges be over-stocked. The ranchman, for the sake of self-preservation, must protect his interests by preventing encroachments upon his chosen territory. Let him unwittingly allow his range to become strong just so soon does he tempt his neighbor, or invite a newcomer who has had no lessons in range courtesies, to divide the range with him. But with individual ownership or with the inauguration of a leasing system whereby an individual could control a given area for a specified term of years, self-interest in most cases, would operate against the present wasteful methods and a far better product could be secured.

Second. Raising the standard of the herd by the infusion of better blood and by sending to the butcher inferior individuals among the breeding herd. Progressive ranchmen have for some time availed themselves of such means for the improvement of their stock and it has had not a little influence in holding prices firm, aside from creating an additional revenue from the sale of breeding stock.

Third. Diversity in stock-raising by the introduction of more than one class of stock upon the range. This is not likely to increase the price received for individual animals but it will, where water is plentiful and the range large,

greatly increase the total revenue. Cattle and horses form a good combination. The introduction of horses may almost double the range area for it is a recognized fact that horses do, with ease, travel twice as far for food and water as cattle. There is a tendency among some to turn much of their attention to the raising of horses or mules. If size be maintained, upon a good foundation stock, such an enterprise is likely to prove remunerative.

The angora goat industry is coming into considerable prominence. In fact the industry has made rather more than expected progress. Since goats prefer to browse upon the leaves, twigs, buds, et cetera, to be found abundantly among the rocks and cañons of the mountain ranges, they do not trespass upon the valley and plain. Cattle, horses and goats may be handled by one ranchman. Cattle feed near the water, horses range far out on the plains, while the goats seek the hilly and mountainous areas. None need trespass upon the territory of the other providing separate watering places are maintained.

Fourth. Feeding range grown stock upon the valley farms and ranches. This is the proposition in which we are interested in this bulletin and if feeding became general it would probably result beneficially in several ways: it would create an important avenue for the disposal of range stock; it would lessen the number of stockers that must meet competition from other sections in our large markets; it would afford the valley farmer an easy and convenient way to market large quantities of grain and forage; and further, our home markets could be supplied from the products of our own soil.

#### MARKETS

The stock grown upon the ranges of the Territory find three principle outlets:

1. The large eastern markets.
2. Ranges further north and in California.
3. The local markets.

Stock shipped to the Kansas City or Chicago markets must

meet the competition from other sections somewhat more favorably situated as regards rainfall and freight rates. The demand for stock to be finished upon the ranges further north and in California is irregular, depending almost wholly upon the rainfall there. Local markets pay no more and often less than can be secured elsewhere. Local buyers discriminate little between classes for butchering purposes, and yet large quantities of the better class of meat are imported from Kansas City and from the cotton producing sections of Texas. Farmers who feed must either sell to the local dealers, often receiving a price low when compared with the price the dealers receive for the meat or ship to the packing-house markets. The latter, in many sections of the Territory, would prove unprofitable owing to the long hauls through a mountainous country under which condition the shrinkage would be heavy because of the long time spent in transit. The high freight rates through such a region and the competition from sections more favorably situated would further operate against shipping. These same conditions, however, should operate in favor of feeding for the local markets, at least, until the home markets are supplied, except when dealers taking advantage of the conditions pay less for the home fed product than they must pay for the imported article of equal quality.

Further, feeding should have a reciprocal effect upon the alfalfa market. Every ton of hay disposed of in the form of meat would leave just that much less to be sold on the open market. If one-half of the alfalfa hay of the valley were fed each year to cattle, sheep and hogs, the price of the other half through the effect of supply and demand would be enhanced. It would raise the price of hay in the same way that a half crop causes the price to rise. We have as an illustration the season of 1902, when the price of alfalfa hay rose to \$15.00 per ton in March of the following spring.

Market quotations show that the price of stockers at the present time is at a very low ebb. This is caused in a measure, at least, by the high price of feed and the rushing to

market of large numbers of poorly finished animals, thus glutting it with an inferior product. A reaction will eventually follow, and better prices will prevail. The outlook for the future in New Mexico is rather encouraging. Through the aid of the irrigation act the cultivated areas will be greatly increased in the next few years. This will result in an increase in the population,—largely agricultural, which will become consumers of meat and feeders of range grown stock. At the same time the range areas will be decreased by the amount of land brought under cultivation.

### OBJECTS OF THE EXPERIMENTS

1. To determine whether feeding cattle and sheep for market in this and similar valleys of New Mexico is feasible.
2. To make a study of the feeds available in order to determine the best for feeding purposes under the prevailing conditions.
3. To determine the best class of range stock for feeding.

### CONDITIONS AND EQUIPMENT

The mild winter weather prevailing in most of the valleys of New Mexico render unnecessary the expense of providing shelter for feeding stock, more than to supply a wind-break, which is necessary only when the feeding is to continue through the windy month of March. The wind-break may be constructed of the most inexpensive material,—a tight board fence or even a rick of corn or kafir-corn stover would serve the purpose admirably.

The feeding pens and the hay racks need not entail a great expense. When hay is fed from the stack it is a common practice to fence in a lot around the stacks, leaving an opening between the boards of the fence on the side next to the stacks through which the cattle or sheep, as the case may be, may secure the hay which is strewn upon the ground just inside. This method affords the greatest economy of labor and material in building the pens and racks, and furthermore, it

provides a most convenient and labor-saving way of supplying the hay to the stock.

#### THE STATION EXPERIMENTS

**The Feeding Pens.**—The feeding pens for the steers were 16 feet wide and 32 feet long made of 2-inch by 6-inch pine lumber. The sheep pens were 12 feet wide and 40 feet long made of 1-inch by 6-inch pine lumber with a board shed 10 feet by 10 feet connected with each pen provided with an opening large enough for the lambs to enter.

**The Racks.**—The feeding racks for the hay for both the steers and the lambs were placed just outside of the fence at the end of each pen. The fence formed the front, the back was made of inch lumber and the ground formed the bottom. The boards on the fence were so placed as to leave a space through which the stock could reach the hay.

**The Grain Troughs.**—The grain troughs for the steers were 10 feet long,  $2\frac{1}{2}$  feet wide and 6 inches deep, supported upon legs of suitable height. The grain trough for the lambs was 16 feet long, 10 inches wide and  $4\frac{1}{2}$  inches deep, with a strip running the whole length of the trough about 10 inches above the middle which prevented the lambs from getting into it while they were eating the grain.

**Weighing.**—The weights were all made with a pair of ordinary wagon scales which were located near the feeding pens. The scales were frequently tested. A chute connected the steer pens and the scales. Good water, which was kept before both the steers and the lambs all of the time, was drawn from a storage tank.

**Waste.**—The hay not consumed was weighed and deducted from the amount given. This waste was fed to stock cattle on the farm and it was practically all consumed by them. No account was taken of the food thrown out of the troughs and trampled under foot, and therefore, it is included with the amount consumed.

**Labor.**—No charge is made for the labor in feeding. It is believed that the labor connected with feeding the hay to the

steers and lambs on the farm would be less than the cost of hauling it to the station and loading it in the car. The value of the manure if spread upon the land would go far toward squaring the labor account.

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## EXPERIMENTS WITH STEERS

1901-2

### DESCRIPTION OF STEERS

The experiment was made with nine, long yearling steers purchased from Mr. J. D. Isaacks, of Las Cruces, New Mexico. The steers were raised on his range located in and west of the Organ mountains. The purchase was made in the fall, the regular round-up and delivery having been made late in the previous spring, and therefore, the steers were not as even a lot as was desired.

### PRICE PAID AND RECEIVED

The price paid, \$20.00 per head, was a little above the ruling prices, but it would have been impossible to buy so small a number for what they were really worth. The cost of riding the range and gathering a small number is nearly as great as it would be for gathering a much larger number. This of course cuts the profits somewhat but no reduction has been made on account of it.

The steers were in good condition for the local market when sold. They brought five cents per pound live weight on April 21st.

### DIVISION

The steers were divided into three lots of three steers each as nearly equal in weight and quality as possible. Each lot was weighed at the beginning and once a week thereafter to the end of the test. The weighing was done at 2 o'clock p. m. The steers were handled quietly and after the first week or so they ceased to be unduly afraid of the feeder but were always nervous upon being removed from their pens for weighing.

### FEEDS

The alfalfa hay was purchased in the valley at \$7.00 per ton baled and delivered. Ten tons of it had been slightly bleached on top when in the wind-row before baling. Its feeding value was probably only slightly diminished by the bleaching, since only a small portion was affected, and yet it would not have gone on the market as first-class hay. The rest of the hay was first-class.

The corn and kafir-corn stover were raised on the Station farm and for the experiment were estimated at \$4.00 per ton shredded. This is probably a little above the cost of production for the kafir-corn stover and considerably above the cost of corn stover. The corn stover was from a field of Hickory King corn which yielded about 25 bushels of grain per acre. The stover was shredded,—enough being shredded at one time to last about two weeks. The corn stover was badly bleached by rain when in the field. The kafir-corn stover was of an excellent quality when freshly shredded but it was found to deteriorate rapidly. It was found next to impossible to get it dry at this season of the year before it was attacked by mould. This rendered it more or less unpalatable and only a small quantity was consumed by the steers. Salt was kept by the steers all of the time.

Lot 1 was fed alfalfa hay alone.

Lot 2 was fed alfalfa hay and shredded kafir-corn stover.

Lot 3 was fed alfalfa hay and shredded corn stover.

### THE FEEDING PERIOD

The test was begun on October 12th, 1901, and continued for six months and nine days, or 192 days, closing on April 21st, 1902.

### MARKET DEMANDS

The local markets do not demand a finished product as does the packing-house markets. Local dealers are not prepared to profitably utilize the offal or the excess of fat from a well finished carcass, therefore, they prefer animals only about

one-half finished. This class of meat can be produced without grain if the feeding period is long enough. Alfalfa hay alone produces meat that is rather soft and the addition of some grain will not only result in a better product but in the end will usually pay.

### TABLES

It has been the purpose of the writer in making up the tables for this bulletin to present the data in such varied form that it can be easily studied by the feeder. This has made a number of tables necessary.

Alfalfa is the most important crop in New Mexico, and for that reason, it is likely to form a large part of any feeding ration. In the tables alfalfa hay, besides being figured at the market price at the time of purchase, is also figured at the cost of production baled f. o. b. the car, and at cost in the stack on the farm. After alfalfa has been baled and stored low prices may render feeding it advisable. In sections where feeding has become an assured industry feeding from the stack has been found to be the best and most economic method, all things considered. Stacking hay when it is to be used for feeding has the following advantages over that of baling it in the field.

1. It costs less to produce the hay.
2. The alfalfa can be removed from the field sooner.
3. More of the leaves, the most nutritious portion of the plants, can be saved.
4. Water can be applied sooner after cutting, thus increasing the yield for the season.

Objections to stacking have arisen from the great waste that is common by this method of storing hay. The waste, however, can be minimized by the use of inexpensive stack covers which can be made of canvas or lumber or by building open sheds consisting of a roof supported upon tall telephone poles. The latter is the better wherever feeding, as an industry, is established.



Whether the hay is stacked in the open or under sheds, improved labor-saving machinery, such as loaders, stackers, forks, et cetera can be profitably used.

Table I.—Financial Statement

STEERS 1901-2

Showing the profit on each lot with alfalfa hay figured as follows: At the market price on board car, at cost on board car, at cost in the stack on the farm.

|        |                                                    | Alfalfa hay, baled, at \$7.00 per ton. Kafir-corn Stover and Corn Stover, shredded, at \$4.00 per ton. |          | Alfalfa hay, baled, at \$3.50 per ton. Kafir-corn Stover and Corn Stover, shredded, at \$4.00 per ton. |          | Alfalfa hay, in stack at \$2.50 per ton. Kafir-corn Stover and Corn Stover, shredded, at \$4.00 per ton. |          |
|--------|----------------------------------------------------|--------------------------------------------------------------------------------------------------------|----------|--------------------------------------------------------------------------------------------------------|----------|----------------------------------------------------------------------------------------------------------|----------|
|        |                                                    | Dr.                                                                                                    | Cr.      | Dr.                                                                                                    | Cr.      | Dr.                                                                                                      | Cr.      |
| Lot 1. | By 3 steers, 2704.6 pounds live weight at 5c. .... |                                                                                                        | \$135.23 |                                                                                                        | \$135.23 |                                                                                                          | \$135.23 |
|        | To 3 steers at \$20.00 per head .....              | \$60.00                                                                                                |          | \$60.00                                                                                                |          | \$60.00                                                                                                  |          |
|        | To 13967.5 pounds alfalfa hay .....                | 48.96                                                                                                  | 108.96   | 24.48                                                                                                  | 84.48    | 17.48                                                                                                    | 77.48    |
|        | Profit .....                                       |                                                                                                        | \$ 26.27 |                                                                                                        | \$ 50.75 |                                                                                                          | \$ 57.75 |
| Lot 2. | By 3 steers, 2800 pounds live weight at 5c. ....   |                                                                                                        | 140.00   |                                                                                                        | 140.00   |                                                                                                          | 140.00   |
|        | To 3 steers at \$20.00 per head .....              | 60.00                                                                                                  |          | 60.00                                                                                                  |          | 60.00                                                                                                    |          |
|        | To 12228 pounds alfalfa hay .....                  | 42.80                                                                                                  |          | 21.40                                                                                                  |          | 15.29                                                                                                    |          |
|        | To 486 pounds kafir-corn stover .....              | 1.69                                                                                                   | 104.49   | 1.69                                                                                                   | 83.09    | 1.69                                                                                                     | 76.98    |
|        | Profit .....                                       |                                                                                                        | \$ 35.51 |                                                                                                        | \$ 56.81 |                                                                                                          | \$ 63.02 |
| Lot 3. | By 3 steers, 2590.6 pounds live weight at 5c. .... |                                                                                                        | 129.53   |                                                                                                        | 129.53   |                                                                                                          | 129.53   |
|        | To 3 steers at \$20.00 per head .....              | 60.00                                                                                                  |          | 60.00                                                                                                  |          | 60.00                                                                                                    |          |
|        | To 11572.5 pounds alfalfa hay .....                | 40.50                                                                                                  |          | 20.25                                                                                                  |          | 14.47                                                                                                    |          |
|        | To 453 pounds corn stover .....                    | .90                                                                                                    | 101.40   | .90                                                                                                    | 81.15    | .90                                                                                                      | 75.37    |
|        | Profit .....                                       |                                                                                                        | \$ 28.13 |                                                                                                        | \$ 48.38 |                                                                                                          | \$ 54.16 |

Table I, besides showing the amount of the different kinds of food consumed and the net profit on each lot with alfalfa hay figured at its actual cost upon the local market, also,

shows the net profit with alfalfa reckoned at the cost of production baled and stored and at cost in the stack.

Like information in regard to the lambs fed can be found in Table IX, and for the second trial with steers in Table XVI.

**Table II.—Feeds Consumed**

STEERS 1901-2

|                                                    | Lot 1<br>Pounds | Lot 2<br>Pounds | Lot 3<br>Pounds |
|----------------------------------------------------|-----------------|-----------------|-----------------|
| Total alfalfa.....                                 | 13987.5         | 12228.          | 11572.          |
| Total kafir-corn stover.....                       |                 | 846.            |                 |
| Total corn stover.....                             |                 |                 | 453.            |
| Total feed.....                                    | 13987.5         | 13074.          | 12025.          |
| Average daily roughage per head (192 days).....    | 24.28           | 22.69           | 20.87           |
| Average roughage per head per month (30 days)..... | 728.5           | 680.9           | 626.3           |
| Nutritive ratio.....                               | 1:3.8           | 1:4.1           | 1:3.9           |

**Table III.—Weights and Gains**

STEERS 1901-2

|                                                      | Lot 1    | Lot 2    | Lot 3    |
|------------------------------------------------------|----------|----------|----------|
| Weight at beginning of test.....                     | 1920.    | 1942.    | 1920.    |
| Weight at end of test.....                           | 2704.6   | 2800.    | 2590.6   |
| Total gain.....                                      | 784.6    | 858.     | 670.6    |
| Average gain per head.....                           | 261.5    | 286.     | 223.5    |
| Average daily gain per head (192 days).....          | 1.36     | 1.49     | 1.16     |
| Average daily gain per 1,000 pounds live weight..... | 2.13     | 2.30     | 1.82     |
| Pounds food to make 1 pound gain.....                | 17.82    | 15.23    | 17.93    |
| Pounds food to make 100 pounds gain.....             | 1782.    | 1523.    | 1793.    |
| Cost of 1 pound gain*.....                           | \$ .0624 | \$ .0518 | \$ .0617 |
| Cost of 100 pounds gain.....                         | \$6.24   | \$5.18   | \$6.17   |

\* Alfalfa, baled, \$7.00 per ton, kafir-corn and corn stover, shredded, estimated at \$4.00 per ton.

**Table IV.—Comparison, by lots, between the rations composed of Alfalfa; Alfalfa and Kafir-corn Stover; and Alfalfa and Corn Stover.**

STEERS 1901-2

|                                                               | Lot 1<br>Alfalfa | Lot 2<br>Alfalfa<br>and Ka-<br>fir-corn<br>Stover | Lot 3<br>Alfalfa<br>and Corn<br>Stover |
|---------------------------------------------------------------|------------------|---------------------------------------------------|----------------------------------------|
| Total pounds gained.....                                      | 784.6            | 858.                                              | 670.6                                  |
| Average gain per head. ....                                   | 261.5            | 286.                                              | 223.5                                  |
| Average daily gain per head (192 days).....                   | 1.36             | 1.49                                              | 1.16                                   |
| Average daily gain per 1000 pounds live weight.....           | 2.13             | 2.30                                              | 1.82                                   |
| Pounds roughage to make 100 pounds gain.....                  | 1782.            | 1523.                                             | 1793.                                  |
| Pounds roughage to make 1 pound gain .....                    | 17.82            | 15.23                                             | 17.93                                  |
| Cost of 100 pounds gain (*alfalfa hay at \$7.00 per ton)..... | \$ 5.24          | \$ 5.18                                           | \$ 6.17                                |
| Cost of 100 pounds gain (*alfalfa hay at \$3.50 per ton)..... | 3.12             | 2.69                                              | 3.15                                   |
| Cost of 100 pounds gain (*alfalfa hay at \$2.50 per ton)..... | 2.23             | 1.98                                              | 2.29                                   |
| Return per ton for alfalfa hay .....                          | 10.71            | 12.81                                             | 11.86                                  |
| Return per acre for alfalfa hay**.....                        | 32.13            | 38.43                                             | 35.58                                  |
| Cost of steers per head.....                                  | 20.00            | 20.00                                             | 20.00                                  |
| Selling price per head.....                                   | 45.08            | 46.66                                             | 43.17                                  |
| Cost of food per head (*alfalfa hay at \$7.00 per ton).....   | 16.32            | 14.83                                             | 13.80                                  |
| Profit per head (*alfalfa hay at \$7.00 per ton).....         | 8.76             | 11.84                                             | 9.38                                   |
| Cost of food per head (*alfalfa hay at \$3.50 per ton).....   | 8.16             | 7.70                                              | 7.06                                   |
| Profit per head (*alfalfa hay at \$3.50 per ton).....         | 16.92            | 18.97                                             | 16.13                                  |
| Cost of food per head (*alfalfa hay at \$2.50 per ton).....   | 5.83             | 5.66                                              | 5.12                                   |
| Profit per head (*alfalfa hay at \$2.50 per ton).....         | 19.25            | 21.01                                             | 18.05                                  |
| Average per cent. of dressed weight.....                      | 53.24            | 52.12                                             | 51.30                                  |

\* Shredded kafir-corn and corn stover, estimated at \$1.00 per ton.

\*\* Reckoned at an average yield of three tons per acre per year.

The results given in Table IV show the value of corn and kafir-corn stover when fed with alfalfa hay. In every essential point the results show that an addition to the alfalfa of a small amount of corn or kafir-corn stover forms a better ration than alfalfa hay alone. Both corn and kafir-corn stover have a wide nutritive ratio, while the nutritive ratio of

alfalfa is very narrow; thus they tend to correct the ration of alfalfa, and to bring it nearer to the recognized standard for fattening steers.

**Table V.—Return per Ton for Alfalfa Hay**

STEERS 1901-2

|                                                        |         |          |
|--------------------------------------------------------|---------|----------|
| <b>Lot 1</b>                                           |         |          |
| By 3 steers, 2704.6 pounds at 5c.....                  |         | \$135.23 |
| To 3 steers at \$20.00 per head.....                   | \$60.00 | 60.00    |
| Balance to the credit of alfalfa hay.....              |         | \$75.23  |
| Received for alfalfa hay per ton.....                  |         | \$10.71  |
| <b>Lot 2</b>                                           |         |          |
| By 3 steers, 2800 pounds at 5c.....                    |         | \$140.00 |
| To 3 steers at \$20.00 per head.....                   | \$60.00 |          |
| To 846 pounds kafir-corn stover at \$1.00 per ton..... | 1.69    | 61.69    |
| Balance to the credit of alfalfa hay.....              |         | \$78.31  |
| Received for alfalfa hay per ton.....                  |         | \$12.81  |
| <b>Lot 3</b>                                           |         |          |
| By 3 steers, 2590.6 pounds at 5c.....                  |         | \$129.53 |
| To 3 steers at \$20.00 per head.....                   | \$60.00 |          |
| To 453 pounds corn stover at \$1.00 per ton.....       | .90     | 60.90    |
| Balance to the credit of alfalfa hay.....              |         | \$68.63  |
| Received for alfalfa hay per ton.....                  |         | 11.88    |

Tables V, XIII and XX show the return per ton for the alfalfa hay fed to the different lots in each experiment. The lambs gave a larger return per ton for the hay consumed than did the steers in either test. This is true, not only of the lots that received alfalfa hay alone, but it is also true of the lots that received other feeds in addition to the alfalfa hay, though the difference is not so great in the latter case.

**Table VI.—Weights and Gains by Periods of One Week**  
STEERS 1901-2

| Date                               | Lot 1         |             | Lot 2                         |             | Lot 3                   |             |
|------------------------------------|---------------|-------------|-------------------------------|-------------|-------------------------|-------------|
|                                    | Alfalfa       |             | Alfalfa and Kafir-corn Stover |             | Alfalfa and Corn Stover |             |
|                                    | Weight Pounds | Gain Pounds | Weight Pounds                 | Gain Pounds | Weight Pounds           | Gain Pounds |
| Oct. 12, 1901.....                 | 1920          |             | 1942                          |             | 1920                    |             |
| " 19, "                            | 1960          | 40          | 2088                          | 96          | 1942                    | 22          |
| " 26, "                            | 1982          | 22          | 2008                          | -30         | 1928                    | -14         |
| Nov. 2, "                          | 1908          | -14         | 2100                          | 92          | 1960                    | 32          |
| " 9, "                             | 2120          | 152         | 2180                          | 80          | 2020                    | 60          |
| " 16, "                            | 2150          | 30          | 2158                          | -22         | 2040                    | 20          |
| " 23, "                            | 2180          | 30          | 2240                          | 82          | 2096                    | 56          |
| " 30, "                            | 2232          | 52          | 2204                          | -36         | 2110                    | 14          |
| Dec. 7, "                          | 2264          | 32          | 2230                          | 26          | 2116                    | 6           |
| " 14, "                            | 2186          | -78         | 2252                          | 22          | 2100                    | -16         |
| " 21, "                            | 2230          | 44          | 2244                          | -8          | 2094                    | -6          |
| " 28, "                            | 2250          | 20          | 2296                          | 52          | 2140                    | 46          |
| Jan. 4, 1902.....                  | 2280          | 30          | 2296                          | -2          | 2108                    | -32         |
| " 11, "                            | 2340          | 60          | 2354                          | 58          | 2210                    | 102         |
| " 17, "                            | 2304          | -36         | 2348                          | -6          | 2176                    | -34         |
| " 25, "                            | 2390          | 86          | 2416                          | 67          | 2288                    | 112         |
| Feb. 1, "                          | 2422          | 32          | 2492                          | 77          | 2306                    | 18          |
| " 8, "                             | 2482          | 60          | 2544                          | 52          | 2348                    | 42          |
| " 15, "                            | 2460          | -22         | 2550                          | 6           | 2370                    | 22          |
| " 22, "                            | 2525          | 65          | 2556                          | 6           | 2370                    | 00          |
| Mch. 1, "                          | 2558          | 33          | 2620                          | 64          | 2400                    | 30          |
| " 8, "                             | 2552          | -6          | 2612                          | -8          | 2446                    | 46          |
| " 15, "                            | 2584          | 32          | 2636                          | 24          | 2458                    | 12          |
| " 22, "                            | 2602          | 18          | 2614                          | 8           | 2482                    | 24          |
| April 5, "                         | 2676          | 74          | 2690                          | 46          | 2534                    | 52          |
| " 11, "                            | 2600          | -76         | 2720                          | 30          | 2542                    | 8           |
| " 19, "                            | 2726          | 126         | 2798                          | 78          | 2616                    | 74          |
| " 26, "                            | 2694          | -32         | 2808                          | 10          | 2782                    | -34         |
| " 21, "                            | 2694          | 00          | 2794                          | -14         | 2574                    | -8          |
| Average of April 19, 20, 21, ..... | 2764%         |             | 2800                          |             | 2590%                   |             |

Table VI shows the weights and gains of each lot by periods of one week. The gains were fairly regular,—the apparent losses, probably, being due to the variation in the amount of water taken before weighing.

The almost universal loss in the weight of the steers, upon daily weighing at the end in both the tests, indicate that possibly the greatest gains cannot be secured with range grown steers if weighed frequently, because of the excitement occasioned in handling the animals.

**Table VII.—Weights and Gains by Periods of Four Weeks**

STEERS 1901-2

| Date               | No. days<br>fed | Lot 1         |             | Lot 2         |             | Lot 3         |             |
|--------------------|-----------------|---------------|-------------|---------------|-------------|---------------|-------------|
|                    |                 | Weight pounds | Gain pounds | Weight pounds | Gain pounds | Weight pounds | Gain pounds |
| Oct. 12, 1901..... | 00              | 1920          |             | 1942          |             | 1920          |             |
| Nov. 9, 1901.....  | 28              | 2120          | 200         | 2180          | 238         | 2020          | 100         |
| Dec. 7, 1901.....  | 56              | 2264          | 144         | 2230          | 50          | 2116          | 96          |
| Jan. 4, 1902.....  | 84              | 2280          | 16          | 2296          | 66          | 2108          | —8          |
| Feb. 1, 1902.....  | 112             | 2422          | 142         | 2492          | 196         | 2306          | 198         |
| Mar. 1, 1902.....  | 140             | 2558          | 136         | 2620          | 128         | 2400          | 94          |
| Mar. 29, 1902..... | 168             | 2602          | 44          | 2644          | 24          | 2482          | 82          |

**Table VIII.—Live and Dressed Weight and per cent. of Dressed Weight**  
**STEERS 1901-2**

| Lot 1.—Alfalfa                       |                    |                       |                                    |
|--------------------------------------|--------------------|-----------------------|------------------------------------|
| Steer No.                            | Live weight Pounds | Dressed weight Pounds | Per cent. of dressed weight Pounds |
| 1                                    | 1046               | 562                   | 53.72                              |
| 2                                    | 840                | 446                   | 53.09                              |
| 3                                    | 762                | 402                   | 52.75                              |
| Total.....                           | 2648               | 1410                  |                                    |
| Average per head..                   | 882%               | 470                   | 53.24                              |
| Lot 2.—Alfalfa and Kafir-corn Stover |                    |                       |                                    |
| 4                                    | 1110               | 584                   | 52.61                              |
| 5                                    | 776                | 406                   | 52.31                              |
| 6                                    | 800                | 410                   | 51.25                              |
| Total.....                           | 2686               | 1400                  |                                    |
| Average per head..                   | 895%               | 466%                  | 52.12                              |
| Lot 3.—Alfalfa and Corn Stover       |                    |                       |                                    |
| 7                                    | 835                | 430                   | 51.49                              |
| 8                                    | 854                | 422                   | 49.41                              |
| 9                                    | 884                | 468                   | 52.94                              |
| Total.....                           | 2573               | 1320                  |                                    |
| Average per head..                   | 857%               | 440                   | 51.30                              |

**EXPERIMENT WITH LAMBS**

1901-2

**DESCRIPTION OF LAMBS**

The experiment with lambs was made with thirty head purchased from Mr. H. Merten, of Hatch, New Mexico. They were selected from the spring crop. They were grades with a mixture of merino blood which showed strongly in several individuals. They were of a fair feeding type and a good strong lot. Medium sized lambs were selected and they averaged about 45 pounds each.

During the ten days following the purchase the whole herd of lambs was allowed to drift southward covering about half of the distance. They were then separated and driven to Mesilla Park a distance of about 22 miles, arriving in good condition although the roads were very heavy, it having rained a good portion of the time. The second day after arrival, November 2nd, the lambs were put into the feeding pens and the test was begun.

**PRICE PAID AND RECEIVED**

The lambs cost \$1.55 per head delivered about one-half the distance. No account was taken of the expense of delivering them the balance of the way for the reason that a larger number would have been delivered the whole distance without extra expense. A carload of such lambs could have been purchased at \$1.35 per head, it is believed, which would have made the results a little better.

At the end of the test all of the lots were in excellent condition for the local markets. They were sold in El Paso, Texas, at five cents per pound on foot, the weights being taken upon arrival without giving either food or water. They were conveyed to El Paso, a distance of about forty miles, in wagons and were on the road thirteen hours, including the stop at noon of about one hour. The thirty lambs made two light loads of a little more than 1,000 pounds each. In the financial statement the cost of delivering is figured on car lots by freight since it is not likely that a less number would be fed



at one time. The expense of hauling in wagons is not unreasonable when a light load of grain or other supplies is brought back on the return trip.

#### DIVISION

The lambs were divided into three lots of ten lambs each as nearly equal in weight and quality as it was possible to divide them. Each lot was weighed once a week at 2 o'clock p. m.

In order to be able to distinguish the lambs, should they break out and become mixed together, they were marked with black spots upon the wool.

#### FEEDS

The source of the feeds for the lambs was the same as for the steers fed during the same winter, except that one lot of lambs received a corn ration in addition to the other feeds. The corn fed was a mixture of dent and flint varieties, but largely of the former. Most of the corn was purchased from native farmers at \$1.50 per fanega. One fanega is equal to 150 pounds, therefore, the corn cost \$1.00 per 100 pounds. Salt was kept by the lambs.

Lot 1 received alfalfa hay alone.

Lot 2 received alfalfa hay, shredded kafir-corn stover, shredded corn stover and corn.

Lot 3 received the same ration as lot 2 except that it received no corn.

Each lot was given all they would eat of hay and stover. Lot 2 was started on a very small amount of corn after they had become accustomed to the alfalfa. The corn ration was very gradually increased to all they would take and clean up.

The lambs were never off feed and there was very little scouring. At one time three lambs of lot 2, when the corn ration was pushed to its highest point, scoured a little but the amount of corn fed was reduced at once and no bad results seemed to follow. Mr. J. W. Bouts, who was in charge of the feeding, deserves commendation for his skillful management of the lambs.

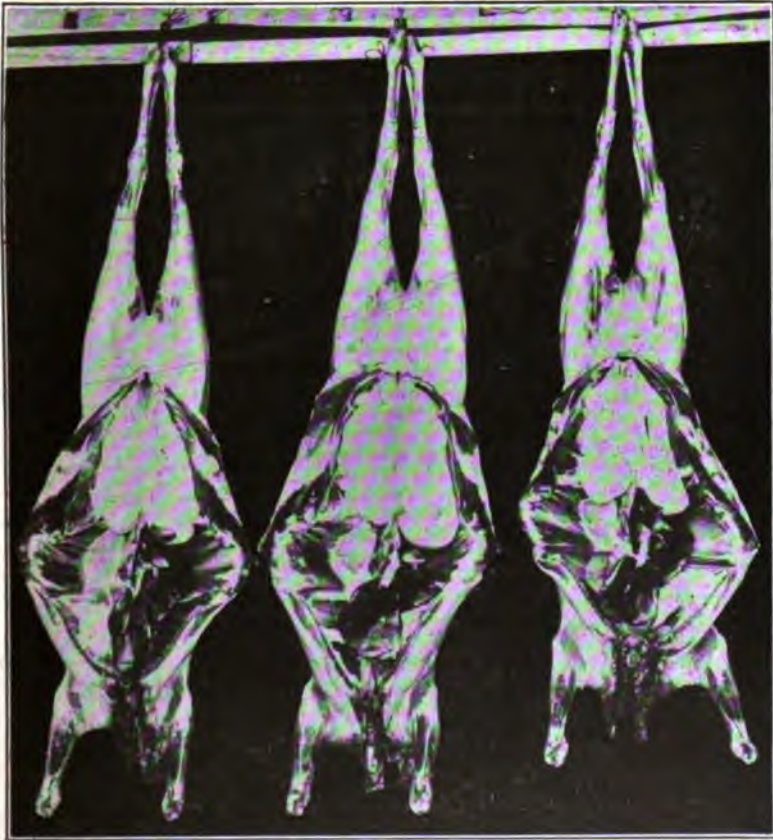
**THE FEEDING PERIOD**

The test was begun on November 2nd, 1901, and continued for 128 days, closing March 9th, 1902. The lambs were in good enough condition to have been sold at an earlier date but the weighing records showed that they were making excellent gains, and as the market was becoming stronger they were held somewhat longer than was absolutely necessary. Plates Nos. I and II represent one lamb from each lot when they were slaughtered.

**MARKETS**

The demand for fat lambs is somewhat more brisk than it is for fat steers. It requires more skill and care in feeding sheep than is required for steer feeding which fact tends to make sheep feeding with many less desirable, but the feeder should bear in mind that rapid gains, quick returns and good prices are usually obtainable for lambs and sheep.

**Plate I**



**Lot 3**  
**Lamb fed on**  
**alfalfa,**  
**kafir-corn stover**  
**and corn stover**

**Lot 2**  
**Lamb fed on**  
**alfalfa,**  
**kafir-corn stover,**  
**corn stover and**  
**corn**

**Lot 1**  
**Lamb fed on**  
**alfalfa**

Table IX.—Financial Statement

LAMBS 1901-2

Showing the profit on each lot with alfalfa hay figured as follows: at the market price on board car, at cost on board car and at cost in the stack on the farm.

|       |                                                   | Alfalfa hay, baled, at \$7.00 per ton. Kafir-corn Stover and Corn Stover, shredded, at \$4.00 per ton. |         | Alfalfa hay, baled, at \$3.50 per ton. Kafir-corn Stover and Corn Stover, shredded, at \$4.00 per ton. |         | Alfalfa hay, in stack, at \$2.50 per ton, Kafir-corn Stover and Corn Stover, shredded, at \$4.00 per ton. |         |
|-------|---------------------------------------------------|--------------------------------------------------------------------------------------------------------|---------|--------------------------------------------------------------------------------------------------------|---------|-----------------------------------------------------------------------------------------------------------|---------|
|       |                                                   | Dr.                                                                                                    | Cr.     | Dr.                                                                                                    | Cr.     | Dr.                                                                                                       | Cr.     |
| Lot 1 | By 10 lambs, 656.25 pounds live weight at 5c..... |                                                                                                        | \$32.81 |                                                                                                        | \$32.81 |                                                                                                           | \$32.81 |
|       | To 10 lambs at \$1.55 per head.....               | \$15.50                                                                                                |         | \$15.50                                                                                                |         | \$15.50                                                                                                   |         |
|       | To 2311 pounds alfalfa hay.....                   | 9.84                                                                                                   |         | 4.92                                                                                                   |         | 3.51                                                                                                      |         |
|       | To loading and freight....                        | .60                                                                                                    | 25.91   | .60                                                                                                    | 21.02   | .60                                                                                                       | 19.61   |
|       | Profit.....                                       |                                                                                                        | \$8.67  |                                                                                                        | \$11.79 |                                                                                                           | \$13.29 |
| Lot 2 | By 10 lambs, 722 pounds live weight at 5c.....    |                                                                                                        | \$36.10 |                                                                                                        | \$36.10 |                                                                                                           | \$36.10 |
|       | To 10 lambs at \$1.55 per head.....               | \$15.50                                                                                                |         | \$15.50                                                                                                |         | \$15.50                                                                                                   |         |
|       | To 1240 pounds alfalfa hay.....                   | 4.34                                                                                                   |         | 2.17                                                                                                   |         | 1.55                                                                                                      |         |
|       | To 450 pounds kafir-corn and corn stover.....     | .90                                                                                                    |         | .90                                                                                                    |         | .90                                                                                                       |         |
|       | To 1083 5 pounds corn at \$20.00 per ton.....     | 10.53                                                                                                  |         | 10.53                                                                                                  |         | 10.53                                                                                                     |         |
|       | To loading and freight....                        | .60                                                                                                    | 31.87   | .60                                                                                                    | 29.70   | .60                                                                                                       | 29.08   |
|       | Profit.....                                       |                                                                                                        | \$4.23  |                                                                                                        | \$6.40  |                                                                                                           | \$7.62  |
| Lot 3 | By 10 lambs, 633 33 pounds live weight at 5c..... |                                                                                                        | \$29.17 |                                                                                                        | \$29.17 |                                                                                                           | \$29.17 |
|       | To 10 lambs at \$1.55 per head.....               | \$15.50                                                                                                |         | \$15.50                                                                                                |         | \$15.50                                                                                                   |         |
|       | To 1954 pounds alfalfa hay.....                   | 6.84                                                                                                   |         | 3.42                                                                                                   |         | 2.44                                                                                                      |         |
|       | To 578 pounds kafir-corn and corn stover.....     | 1.15                                                                                                   |         | 1.15                                                                                                   |         | 1.15                                                                                                      |         |
|       | To loading and freight....                        | .60                                                                                                    | 21.09   | .60                                                                                                    | 20.67   | .60                                                                                                       | 19.69   |
|       | Profit.....                                       |                                                                                                        | \$5.08  |                                                                                                        | \$6.50  |                                                                                                           | \$6.48  |

**Plate II**



**Lot 3**  
**Lamb fed on**  
**alfalfa,**  
**kafir-corn stover**  
**and corn stover**

**Lot 2**  
**Lamb fed on**  
**alfalfa,**  
**kafir-corn stover,**  
**corn stover and**  
**corn**

**Lot 1**  
**Lamb fed on**  
**alfalfa**

## STEER AND LAMB FEEDING

**Table X.—Feeds Consumed**  
LAMBS 1901-2

|                                                    | Lot 1<br>Pounds | Lot 2<br>Pounds | Lot 3<br>Pounds |
|----------------------------------------------------|-----------------|-----------------|-----------------|
| Total alfalfa hay.....                             | 2811.           | 1240.           | 1864.           |
| Total kafir-corn and corn stover.....              | ....            | 450.            | 578.            |
| Total corn.....                                    | ....            | 1053.5          | ....            |
| Total feed.....                                    | 2811.           | 2743.5          | 2532.           |
| Average daily roughage per head (128 days).....    | 2.2             | 1.32            | 1.98            |
| Average roughage per head per month (30 days)..... | 66.             | 39.6            | 59.4            |
| Nutritive ratio.....                               | 1:3.8           | 1:5.5           | 1:4.6           |

**Table XI.—Weights and Gains**  
LAMBS 1901-2

|                                                     | Lot 1    | Lot 2    | Lot 3    |
|-----------------------------------------------------|----------|----------|----------|
| Weight at beginning of test.....                    | 450.     | 458.     | 450.     |
| Weight at end of test.....                          | 687.3    | 757.3    | 634.6    |
| Total gain.....                                     | 237.3    | 299.3    | 184.6    |
| Average gain per head.....                          | 23.73    | 29.93    | 18.46    |
| Average daily gain per head (128 days).....         | .185     | .233     | .144     |
| Average daily gain per 1000 pounds live weight..... | 4.12     | 5.10     | 3.20     |
| Pounds food to make 1 pound gain.....               | 11.845   | 9.166    | 13.716   |
| Pounds food to make 100 pounds gain.....            | 1184.5   | 916.6    | 1371.6   |
| Cost of 1 pound gain*.....                          | \$ .0415 | \$ .0527 | \$ .0433 |
| Cost of 100 pounds gain.....                        | \$4.15   | \$5.27   | \$4.33   |

\* Alfalfa hay, baled, \$7.00 per ton, kafir-corn and corn stover, shredded, estimated at \$4.00 per ton

Table XI, giving the weights and gains for the lambs fed, brings out the interesting point that all of the lots returned not only a total net profit on the feed consumed but also made the gains at a profit, with the exception of lot 2; that is, the gains were made for less than five cents per pound, the price received for the lambs. A further study of the table shows that for every 1000 pounds live weight at the beginning of the test the average daily gain for the different lots was as follows: Lot 1, 4.12 pounds, lot 2, 5.11 pounds and lot 3, 3.30

pounds. Lot 1, which received alfalfa hay alone made the cheapest gains; lot 3, which had stover in addition to the hay stands next in cost of gain; and lot 2, which had a corn ration made the costliest gains of all. The high price of the corn probably was the cause of the comparatively high cost of the gains.

**Table XII.—Comparison by lots between the rations composed of Alfalfa; Alfalfa, Kafir-corn Stover, Corn Stover and Corn; and Alfalfa, Kafir-corn Stover and Corn Stover.**

LAMBS 1901-2

|                                                               | Lot 1<br>Alfalfa | Lot N. 2<br>Alfalfa,<br>Kafir-<br>corn Stover, Corn<br>Stover and Corn | Lot No. 3<br>Alfalfa,<br>Kafir-<br>corn<br>Stover and Corn<br>Stover |
|---------------------------------------------------------------|------------------|------------------------------------------------------------------------|----------------------------------------------------------------------|
| Total pounds gained.....                                      | 237.3            | 209.3                                                                  | 184.6                                                                |
| Average gain per head.....                                    | 23.73            | 29.93                                                                  | 18.46                                                                |
| Average daily gain per head (128 days).....                   | .185             | .233                                                                   | .144                                                                 |
| Average daily gain per 1000 pounds live weight.....           | 4.12             | 5.10                                                                   | 3.20                                                                 |
| Pounds roughage to make 100 pounds gain.....                  | 1184.5           | 564.6                                                                  | 1371.6                                                               |
| Pounds roughage to make 1 pound gain.....                     | 11.845           | 5.646                                                                  | 13.716                                                               |
| Pounds food to make 100 pounds gain.....                      | 1184.5           | 916.6                                                                  | 1371.6                                                               |
| Pounds food to make 1 pound gain.....                         | 11.845           | 9.166                                                                  | 13.716                                                               |
| Cost of 100 pounds gain (*alfalfa hay at \$7.00 per ton)..... | \$ 4.15          | \$ 5.27                                                                | \$ 4.33                                                              |
| Cost of 100 pounds gain (*alfalfa hay at \$3.50 per ton)..... | 2.07             | 4.54                                                                   | 2.48                                                                 |
| Cost of 100 pounds gain (*alfalfa hay at \$2.50 per ton)..... | 1.48             | 4.34                                                                   | 1.94                                                                 |
| Return per ton for alfalfa hay.....                           | 11.89            | 13.82                                                                  | 11.92                                                                |
| Return per acre for alfalfa hay **.....                       | 35.67            | 41.46                                                                  | 35.76                                                                |
| Selling price per head.....                                   | 3.22             | 3.55                                                                   | 2.86                                                                 |
| Cost of lambs per head.....                                   | 1.55             | 1.55                                                                   | 1.55                                                                 |
| Cost of food per head (*alfalfa hay at \$7.00 per ton).....   | .98              | 1.58                                                                   | .80                                                                  |
| Profit per head (*alfalfa hay at \$7.00 per ton).....         | .60              | .42                                                                    | .51                                                                  |
| Cost of food per head (*alfalfa hay at \$3.50 per ton).....   | \$ .49           | \$ 1.36                                                                | \$ .46                                                               |
| Profit per head (*alfalfa hay at \$3.50 per ton).....         | 1.18             | .64                                                                    | .85                                                                  |
| Cost of food per head (*alfalfa hay at \$2.50 per ton).....   | .35              | 1.30                                                                   | .36                                                                  |
| Profit per head (*alfalfa hay at \$2.50 per ton).....         | 1.32             | .70                                                                    | .98                                                                  |
| Average per cent. of dressed weight.....                      | 48.28            | 54.31                                                                  | 47.34                                                                |

\* Shredded kafir-corn and corn stover, estimated at \$4.00 per ton.

\*\* Reckoned at an average yield of three tons per acre per year.

Table XIII.—Return per Ton for Alfalfa Hay

LAMBS 1901-2,

| Lot 1                                                           |         |         |
|-----------------------------------------------------------------|---------|---------|
| By 10 lambs, 656.35 pounds at 5c.....                           |         | \$32.81 |
| To 10 lambs at \$1.55 per head.....                             | \$15.50 |         |
| To loading and freight.....                                     | .60     | 16.10   |
| Balance to the credit of alfalfa hay.....                       |         | \$16.71 |
| Received for alfalfa hay per ton.....                           |         | \$11.83 |
| Lot 2                                                           |         |         |
| By 10 lambs, 722 pounds at 5c.....                              |         | \$36.10 |
| To 10 lambs at \$1.55 per head.....                             | \$15.50 |         |
| To 450 pounds corn and kafir-corn stover at \$4.00 per ton..... | .90     |         |
| To 1053.5 pounds corn at \$20.00 per ton.....                   | 10.53   |         |
| To loading and freight.....                                     | .60     | 27.53   |
| Balance to the credit of alfalfa hay.....                       |         | \$8.57  |
| Received for alfalfa hay per ton.....                           |         | \$13.82 |
| Lot 3                                                           |         |         |
| By 10 lambs, 583.33 pounds at 5c.....                           |         | \$29.17 |
| To 10 lamb at \$1.55 per head.....                              | \$15.50 |         |
| To 573 pounds kafir-corn stover at \$4.00 per ton.....          | 1.15    |         |
| To loading and freight.....                                     | .60     | 17.25   |
| Balance to the credit of alfalfa hay.....                       |         | \$11.92 |
| Received for alfalfa hay per ton.....                           |         | \$12.20 |



Table XIV.—Weights and Gains by Periods of One Week

LAMBS 1901-2

| Date              | Lot 1         |             | Lot 2         |             | Lot 3         |             |
|-------------------|---------------|-------------|---------------|-------------|---------------|-------------|
|                   | Weight pounds | Gain pounds | Weight pounds | Gain pounds | Weight pounds | Gain pounds |
| Nov. 2, 1901..... | 450           |             | 458           |             | 450           |             |
| Nov. 9, "         | 470           | 20          | 468           | 10          | 446           | -4          |
| Nov. 16, "        | 498           | 28          | 500           | 32          | 460           | 14          |
| Nov. 23, "        | 490           | -8          | 500           | 00          | 470           | 10          |
| Nov. 30, "        | 498           | 8           | 512           | 12          | 468           | -2          |
| Dec. 7, "         | 522           | 24          | 534           | 22          | 483           | 20          |
| Dec. 14, "        | 516           | -6          | 520           | -14         | 476           | -12         |
| Dec. 21, "        | 528           | 12          | 548           | 28          | 488           | 12          |
| Dec. 28, "        | 534           | 6           | 564           | 16          | 488           | 00          |
| Jan. 4, 1902..... | 546           | 12          | 580           | 16          | 502           | 14          |
| Jan. 11, "        | 564           | 18          | 594           | 14          | 514           | 12          |
| Jan. 18, "        | 560           | -4          | 610           | 16          | 516           | 2           |
| Jan. 25, "        | 582           | 22          | 620           | 10          | 522           | 6           |
| Feb. 1, "         | 604           | 22          | 646           | 26          | 554           | 32          |
| Feb. 8, "         | 625           | 21          | 675           | 29          | 570           | 16          |
| Feb. 15, "        | 636           | 11          | 700           | 25          | 590           | 20          |
| Feb. 22, "        | 664           | 28          | 714           | 14          | 600           | 10          |
| Mar. 1, "         | 668           | 4           | 740           | 26          | 610           | 10          |
| Mar. 8, "         | 676           | 8           | 744           | 4           | 624           | 14          |
| Mar. 15, "        | 674           | -2          | 746           | 2           | 624           | 00          |
| Mar. 22, "        | 680           | 6           | 750           | 4           | 626           | 2           |
| Mar. 29, "        | 682           | 2           | 744           | -6          | 626           | 00          |
| Mar. 5, "         | 690           | 8           | 762           | 18          | 638           | 12          |
| Mar. 12, "        | 690           | 0           | 766           | 4           | 640           | 2           |

## STEER AND LAMB FEEDING

**Table XV.—Weights and Gains by Periods of Four Weeks**  
**LAMBS 1901-2**

|                    |              | Lot 1         |             | Lot 2         |             | Lot 3         |             |
|--------------------|--------------|---------------|-------------|---------------|-------------|---------------|-------------|
| Date               | No. days fed | Weight pounds | Gain pounds | Weight pounds | Gain pounds | Weight pounds | Gain pounds |
| Nov. 2, 1901.....  | 00           | 450           |             | 458           |             | 450           |             |
| Nov. 30, 1901..... | 28           | 498           | 48          | 512           | 54          | 468           | 18          |
| Dec. 28, 1901..... | 56           | 534           | 36          | 564           | 52          | 488           | 20          |
| Jan. 25, 1902..... | 84           | 582           | 48          | 620           | 56          | 522           | 34          |
| Feb. 22, 1902..... | 112          | 664           | 82          | 714           | 94          | 600           | 78          |

## EXPERIMENT WITH STEERS

1902-3

### DESCRIPTION OF STEERS

The steers for the experiment of the winter of 1902-3, thirty-two head, were purchased from Mr. Charles Gatlin, of Magdalena, New Mexico. They were from a herd of about 800 head that had been transferred from Magdalena to a range near Rincon about two weeks previous to the purchase. The steers were long yearlings and while they had fairly good frames yet they were quite thin in flesh. Except for this fact they would have been a representative lot of range steers. Plates Nos. III, IV, V and VI represent the steers at the time the corn ration was begun March 1st, and when the test ended on April 6th, 1903. The steers were dehorned and marked so that they could be distinguished should they become mixed.

### PRICE PAID AND RECEIVED

Sixteen dollars per head was paid for the steers delivered at the Station farm. This was probably a little more than a larger number would have cost.

The alfalfa hay ran out before the steers were all well finished and the high price of hay at the time precluded the purchase of more for continuing the test. The steers were sold in Las Cruces for seven cents per pound dressed weight. If they had been held longer there is little doubt but that they would have brought a better price for two reasons: all of them would have been well finished and they could have been marketed at a season when good range butcher-stuff is always scarce.

### DIVISION

The steers were divided into four lots of eight steers each as nearly equal in weight and quality as it was possible to divide them. It was the intention to weigh the lots once each

week and also to weigh the individual steers but they were so wild that frequent weighing was abandoned. The weights were made at 10 o'clock a. m.

### FEEDS

The steers were started on good grama hay and very gradually transferred to alfalfa hay. The alfalfa hay was all first-class. The corn fed was white No. 3 or better, purchased from Bossemeyer Bros., Superior, Nebraska. The wheat was grown on the Station farm, and the bran was purchased at a local mill. The corn cost \$1.25 per 100 pounds f. o. b. Mesilla Park and 50c per ton, or 2½c. per 100 pounds, was allowed for delivering it from the depot to the Station farm,—a distance of about one-half mile. The wheat and bran were figured at \$1.00 per 100 pounds, the price paid for the bran and the price at which wheat at the beginning of the milling season is sold. Both the corn and wheat were cracked. Salt was provided for the steers.

Lot 1 received alfalfa hay and about one-third of a full ration of corn.

Lot 2 received alfalfa hay and a full ration of corn.

Lot 3 received alfalfa hay and about one-third of a full ration of a mixture of wheat and bran in the proportion of three parts of wheat to one part of bran by weight.

Lot 4 received alfalfa hay alone.

The lots that received grain were started on a small quantity, the amount being very gradually increased until the desired amount was given.

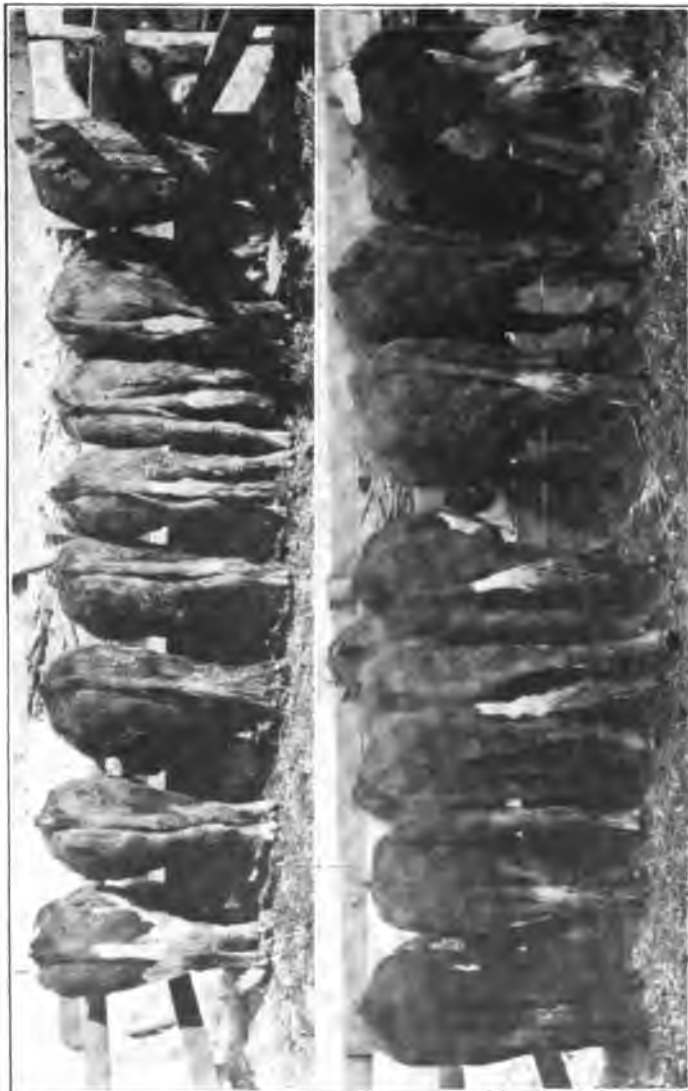
### THE FEEDING PERIOD

The feeding was begun on December 17th, 1902. The lots all received the same ration, alfalfa hay, until the close of February 1903,—a period of 76 days. This gave an opportunity to make a comparison between the lots which were later to receive different rations. The grain ration was begun on March 1st, 1903 and continued until the experiment was closed on April 6th. The total length of the feeding period was 111 days but the period for feeding grain was so short,

for reasons already given, that lot 2 scarcely got on full feed when the test was stopped. The total feeding period was long enough to fit lots 1, 2 and 3 for the local markets, but it was too short in which to fit lot 4 which had only a ration of alfalfa hay. Furthermore, the butcher objected to the meat from lot 4 but made no complaint against that from the other lots.

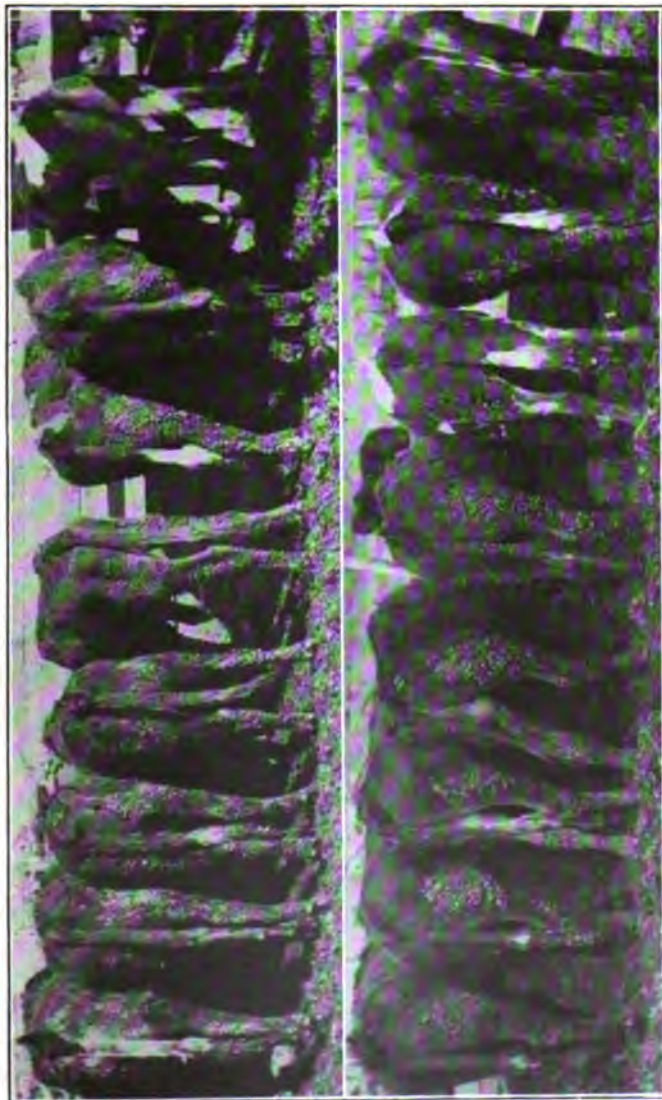
The steers had to learn to eat grain. Most of them gave little or no trouble. Three steers in lot 1, however, refused to eat corn until near the end of the test. While the result obtained from lot 1 are presented in tabular form, no attempt has been made to draw conclusions therefrom.

**Plate III**



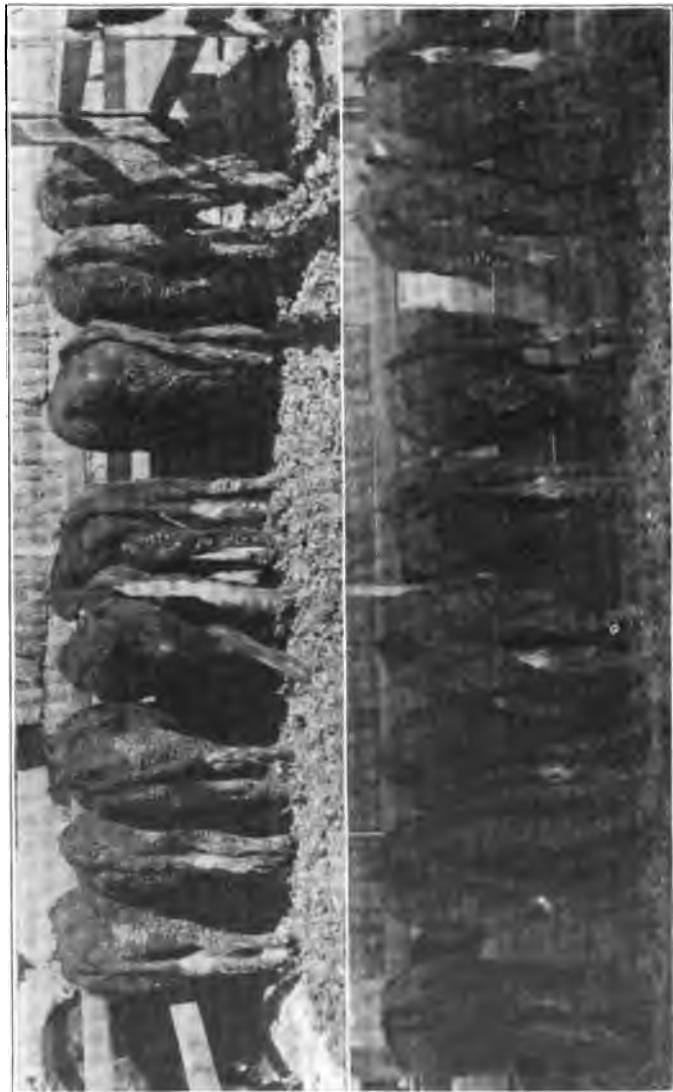
The upper figure represents Lot 1 when grain feeding was begun.  
The lower figure represents Lot 1 at the end of the test.

**Plate IV**



The upper figure represents Lot 2 when grain feeding was begun.  
The lower figure represents Lot 2 at the end of the test.

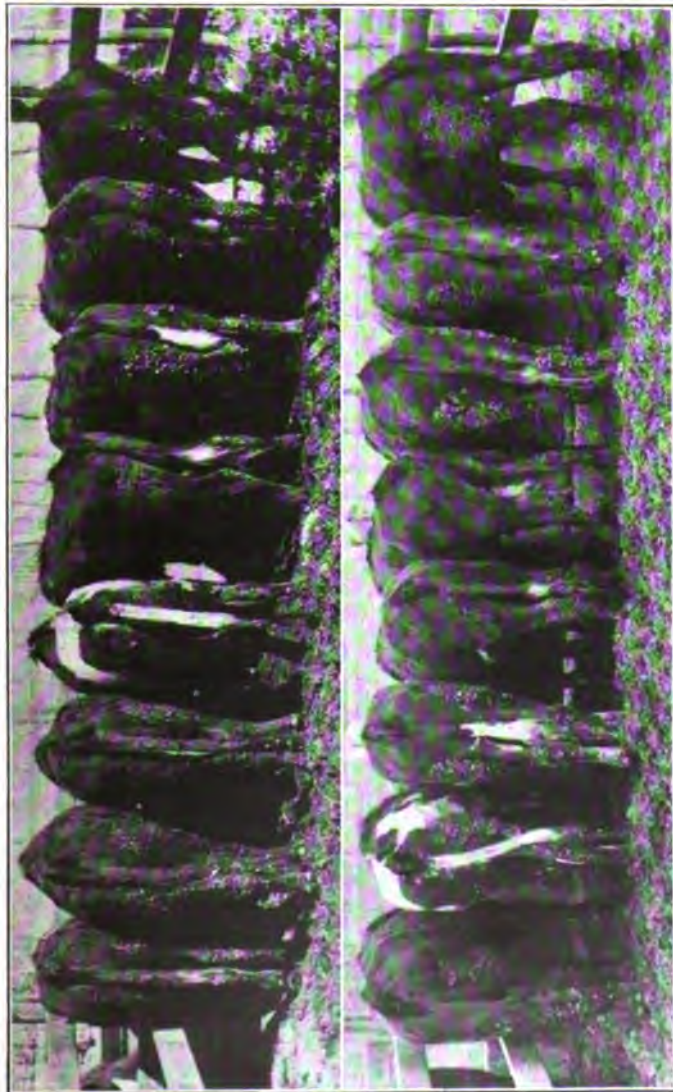
**Plate V**



The upper figure represents Lot 3 when grain feeding was begun.  
The lower figure represents Lot 3 at the end of the test.



**Plate VI**



The upper figure represents Lot 4 when grain feeding was begun with Lots 1, 2 and 3.  
The lower figure represents Lot 4 at the end of the test.

Table XVI.—Financial Statement

STEERS 1902-3

Showing the profit or loss on each lot with alfalfa hay figured as follows: at the market price on board car, at cost on board car and at cost in the stack on the farm.

|       |                                                     | +Alfalfa and grama hay, baled, at \$7.00 per ton. |          | Alfalfa and grama hay, baled, at 3.50 per ton. |          | Alfalfa and grama hay, in stack, at \$2.50 per ton. |          |
|-------|-----------------------------------------------------|---------------------------------------------------|----------|------------------------------------------------|----------|-----------------------------------------------------|----------|
|       |                                                     | Dr.                                               | Cr.      | Dr.                                            | Cr.      | Dr.                                                 | Cr.      |
| Lot 1 | By 8 steers, 2824.17 pounds dressed weight at 7c... |                                                   | \$197.69 |                                                | \$197.69 |                                                     | \$197.69 |
|       | To 8 steers at \$16.00 per head.....                | \$128.00                                          |          | \$128.00                                       |          | \$128.00                                            |          |
|       | To 1460.5 pounds alfalfa hay.....                   | 51.81                                             |          | 25.66                                          |          | 18.33                                               |          |
|       | To 1870.5 pounds grama hay.....                     | 6.55                                              |          | 3.27                                           |          | 2.34                                                |          |
|       | To 1047 pounds corn at \$25.50 per ton.....         | 13.35                                             | 199.21   | 13.35                                          | 170.28   | 13.35                                               | 162.02   |
|       | Profit or loss.....                                 |                                                   | \$1.52*  |                                                | \$27.41  |                                                     | \$35.67  |
| Lot 2 | By 8 steers, 3004.5 pounds dressed weight at 7c...  |                                                   | \$210.32 |                                                | \$210.32 |                                                     | \$210.32 |
|       | To 8 steers at \$16.00 per head.....                | \$128.00                                          |          | \$128.00                                       |          | \$128.00                                            |          |
|       | To 14496 pounds alfalfa hay.....                    | 50.74                                             |          | 25.37                                          |          | 18.12                                               |          |
|       | To 1622 pounds grama hay.....                       | 5.67                                              |          | 2.84                                           |          | 2.08                                                |          |
|       | To 1518 pounds corn at \$25.50 per ton.....         | 19.35                                             | 203.76   | 19.35                                          | 175.56   | 19.35                                               | 167.50   |
|       | Profit.....                                         |                                                   | \$8.56   |                                                | \$34.78  |                                                     | \$42.82  |
| Lot 3 | By 8 steers, 2976.8 pounds dressed weight at 7c...  |                                                   | \$208.38 |                                                | \$208.38 |                                                     | \$208.38 |
|       | To 8 steers at \$16.00 per head.....                | \$128.00                                          |          | \$128.00                                       |          | \$128.00                                            |          |
|       | To 14796 pounds alfalfa hay.....                    | 51.79                                             |          | 25.89                                          |          | 12.50                                               |          |
|       | To 1580 pounds grama hay.....                       | 5.53                                              |          | 2.77                                           |          | 1.97                                                |          |
|       | To 1002 pounds wheat and bran at \$1.00 per 100 bs. | 10.02                                             | 195.34   | 10.02                                          | 166.68   | 10.02                                               | 158.49   |
|       | Profit.....                                         |                                                   | \$15.04  |                                                | \$41.70  |                                                     | \$49.89  |
| Lot 4 | By 8 steers, 2856.7 pounds dressed weight at 7c...  |                                                   | \$199.97 |                                                | \$199.97 |                                                     | \$199.97 |
|       | To 8 steers at \$16.00 per head.....                | \$128.00                                          |          | \$128.00                                       |          | \$128.00                                            |          |
|       | To 15340 pounds alfalfa hay.....                    | 53.69                                             |          | 26.84                                          |          | 19.17                                               |          |
|       | To 1719.5 pounds grama hay.....                     | 6.02                                              | 187.71   | 3.01                                           | 157.85   | 2.15                                                | 149.32   |
|       | Profit.....                                         |                                                   | \$12.26  |                                                | \$42.12  |                                                     | \$50.65  |

\*Grama hay is reckoned at the same price as alfalfa though it is not equal to alfalfa in feeding value.

\*Loss.

**Table XVII.—Weights and Gains**

STEERS 1902-3

|                                                              | Lot 1    | Lot 2    | Lot 3    | Lot 4    |
|--------------------------------------------------------------|----------|----------|----------|----------|
| Weight at beginning of test.....                             | 4450.    | 4360.    | 4344.    | 4322.    |
| Weight at end of test.....                                   | 5530.    | 5774.6   | 5781.3   | 5710.    |
| Total gain.....                                              | 1080.    | 1424.6   | 1437.3   | 1388.    |
| Average gain per head.....                                   | 135.     | 178.     | 179.6    | 173.5    |
| Average daily gain per head (111 days).....                  | 1.22     | 1.60     | 1.62     | 1.56     |
| Average daily gain per 1000 pounds live weight.              | 2.196    | 2.950    | 2.981    | 2.893    |
| Pounds food to make 1 pound gain.....                        | 16.27    | 12.38    | 12.00    | 12.29    |
| Pounds food to make 100 pounds gain .....                    | 1627.    | 1238.    | 1209.    | 1229.    |
| Cost of 1 pound gain (alfalfa hay at \$7.00 per ton)         | \$ .0659 | \$ .0632 | \$ .0468 | \$ .0430 |
| Cost of 100 pounds gain (alfalfa hay at \$7.00 per ton)..... | 6.59     | 5.32     | 4.68     | 4.30     |

Table XVIII.—Comparison Between Lots by Periods

Showing the pounds of food consumed, pounds of food to make one pound gain, cost of one pound gain, average daily roughage per head, average daily food per head and nutritive ratio.

STEERS 192-3

|                                     | 1st Period |         |         |         | 2nd Period |         |         |         | 1st and 2nd Periods |         |         |         |
|-------------------------------------|------------|---------|---------|---------|------------|---------|---------|---------|---------------------|---------|---------|---------|
|                                     | Lot 1      | Lot 2   | Lot 3   | Lot 4   | Lot 1      | Lot 2   | Lot 3   | Lot 4   | Lot 1               | Lot 2   | Lot 3   | Lot 4   |
| Alfalfa hay fed.....                | 9083.      | 9089.   | 9217.   | 9094.   | 3597.5     | 3427.   | 3579.   | 3246.   | 14660.5             | 14496.  | 14796.  | 15340.  |
| Grain hay fed.....                  | 1870.5     | 1622.   | 1580.   | 1719.5  | .....      | .....   | .....   | .....   | 1870.5              | 1622.   | 1580.   | 1719.5  |
| Grain fed.....                      | .....      | .....   | .....   | .....   | 1017.      | 1181.   | 1002.   | .....   | 1017.               | 1518.   | 1002.   | .....   |
| Gain.....                           | 626.       | 697.    | 782.    | 814.    | 454.       | 727.6   | 655.3   | 574.    | 1080.               | 1424.6  | 1437.3  | 1388.   |
| Pounds food to make 1 pound gain.   | 17.46      | 15.34   | 13.81   | 13.28   | 14.63      | 9.55    | 10.04   | 10.88   | 16.27               | 12.38   | 12.09   | 12.29   |
| Cost of 1 pound gain*.....          | \$ .061    | \$ .064 | \$ .048 | \$ .046 | \$ .073    | \$ .063 | \$ .045 | \$ .038 | \$ .066             | \$ .053 | \$ .017 | \$ .043 |
| Average daily roughage per head.... | 18.47      | 18.06   | 18.24   | 18.27   | 18.91      | 18.33   | 18.84   | 21.10   | 18.61               | 18.15   | 18.44   | 19.21   |
| Average daily food per head.....    | 18.47      | 18.06   | 18.24   | 18.27   | 22.44      | 23.46   | 22.23   | 21.10   | 19.70               | 19.86   | 19.57   | 19.21   |
| Nutritive ratio.....                | .....      | .....   | .....   | .....   | 1:4.5      | 1:4.8   | 1:4.3   | 1:3.8   | .....               | .....   | .....   | .....   |

\* Alfalfa hay at \$7.00 per ton.

**Table XIX.—Comparison between Lot 1, fed on alfalfa hay and a light ration of corn; Lot 2, fed on alfalfa hay and a heavy ration of corn; Lot 3, fed on alfalfa hay and a light ration composed of wheat and bran in the proportion of three parts wheat to one part bran by weight; and Lot 4, fed on alfalfa hay alone.**

STEERS 1902-3

|                                                              | Lot 1<br>Alfalfa<br>hay and<br>a light<br>ration of<br>corn | Lot 2<br>Alfalfa<br>hay and<br>a heavy<br>ration of<br>corn | Lot 3<br>Alfalfa<br>hay and<br>a light<br>ration of<br>wheat &<br>bran | Lot 4<br>Alfalfa<br>hay<br>alone |
|--------------------------------------------------------------|-------------------------------------------------------------|-------------------------------------------------------------|------------------------------------------------------------------------|----------------------------------|
| Total pounds gained.....                                     | 1080.                                                       | 1424.6                                                      | 1437.3                                                                 | 1388.                            |
| Average gain per head.....                                   | 135.                                                        | 178.                                                        | 179.                                                                   | 173.5                            |
| Average daily gain per head (111 days).....                  | 1.22                                                        | 1.60                                                        | 1.62                                                                   | 1.56                             |
| Average daily gain per 1000 pounds live weight.....          | 2.186                                                       | 2.960                                                       | 2.981                                                                  | 2.893                            |
| Pounds roughage to make 100 pounds gain.....                 | 1530.                                                       | 1181.                                                       | 1139.                                                                  | 1229.                            |
| Pounds roughage to make 1 pound gain.....                    | 15.30                                                       | 11.31                                                       | 11.39                                                                  | 12.29                            |
| Pounds food to make 100 pounds gain.....                     | 1627.                                                       | 1238.                                                       | 1209.                                                                  | 1229.                            |
| Pounds food to make 1 pound gain.....                        | 16.27                                                       | 12.38                                                       | 12.09                                                                  | 12.29                            |
| Cost of 100 pounds gain (alfalfa hay at \$7.00 per ton)..... | \$ 6.50                                                     | \$ 5.32                                                     | \$ 4.68                                                                | \$ 4.30                          |
| Cost of 100 pounds gain (alfalfa hay at \$8.50 per ton)..... | 3.91                                                        | 3.34                                                        | 2.69                                                                   | 2.16                             |
| Cost of 100 pounds gain (alfalfa hay at \$2.50 per ton)..... | 3.15                                                        | 2.77                                                        | 2.12                                                                   | 1.54                             |
| Return per ton for alfalfa hay **.....                       | 6.82                                                        | 7.81                                                        | 8.59                                                                   | 8.44                             |
| Return per acre for alfalfa hay §.....                       | 20.46                                                       | 23.43                                                       | 25.77                                                                  | 25.32                            |
| Cost of steers per head.....                                 | 16.00                                                       | 16.00                                                       | 16.00                                                                  | 16.00                            |
| Selling price per head.....                                  | 24.71                                                       | 26.29                                                       | 26.05                                                                  | 24.99                            |
| Cost of food per head (alfalfa hay at \$7.00 per ton).....   | 8.90                                                        | 9.47                                                        | 8.42                                                                   | 7.46                             |
| Profit per head (alfalfa hay at \$7.00 per ton)....          | .19*                                                        | .82                                                         | 1.63                                                                   | 1.53                             |
| Cost of food per head (alfalfa hay at \$3.50 per ton).....   | 5.29                                                        | 5.95                                                        | 4.84                                                                   | 3.73                             |
| Profit per head (alfalfa hay at \$3.50 per ton)....          | 3.43                                                        | 4.35                                                        | 5.21                                                                   | 5.27                             |
| Cost of food per head (alfalfa hay at \$2.50 per ton).....   | 4.25                                                        | 4.94                                                        | 3.81                                                                   | 2.67                             |
| Profit per head (alfalfa hay at \$2.50 per ton)....          | 4.46                                                        | 5.35                                                        | 6.24                                                                   | 6.33                             |
| Average per cent. of dressed weight.....                     | 51.07                                                       | 52.03                                                       | 51.49                                                                  | 50.93                            |

\*Loss.

\*\*Grain reckoned at the same price as alfalfa hay.

§Reckoned at an average yield of three tons per acre per year.

Table XIX shows that the gains made by lots 2 and 3 were about equal although lot 2 received the heaviest ration of grain. Why this was so we are unable at the present time to tell. It is safe to say, at least, that alfalfa hay, wheat and bran form a good ration, and since these feeds, as a rule, are somewhat cheaper than corn they may safely form a large part of any fattening ration. Corn fed meat is considered superior to the wheat fed product but for local market demands wheat and bran will prove quite satisfactory as a feed.

Lot 4, that received only alfalfa hay, made the cheapest gains of the four lots. It does not follow from this that it is always best to feed alfalfa hay alone as a careful study of Tables V, XIII and XX will show. With only one exception (as stated before no comparison is made with lot 1) which may perhaps be accounted for by the short feeding period, the return per ton for the alfalfa hay is greater when grain is fed with the alfalfa than when the alfalfa is fed alone. Furthermore, the hay fed meat is inferior to the corn fed product.

If these results are confirmed by future experiments, they will be of considerable value to the feeder, and of special interest to growers of alfalfa since by feeding a grain ration, though comparatively high in price, with the alfalfa hay the hay will bring more per ton than when fed without grain.

Table XX.—Return per Ton for Alfalfa Hay

STEERS 1902-3

| Lot 1                                                 |          |          |
|-------------------------------------------------------|----------|----------|
| By 8 steers, 2324.17 pounds dressed weight at 7c..... |          | \$197.69 |
| To 8 steers at \$16.00 per head.....                  | \$128.00 |          |
| To 1047 pounds corn at \$25.50 per ton.....           | 13.85    | 141.35   |
| Balance to the credit of alfalfa hay.....             |          | \$ 56.34 |
| Received for alfalfa hay per ton*.....                |          | \$ 8.82  |
| Lot 2                                                 |          |          |
| By 8 steers, 3004.59 pounds dressed weight at 7c..... |          | \$210.32 |
| To 8 steers at \$16.00 per head.....                  | \$128.00 |          |
| To 1518 pounds corn at \$25.50 per ton.....           | 19.85    | 147.35   |
| Balance to the credit of alfalfa hay.....             |          | \$ 62.97 |
| Received for alfalfa hay per ton*.....                |          | \$ 7.81  |
| Lot 3                                                 |          |          |
| By 8 steers, 2976.8 pounds dressed weight at 7c.....  |          | \$208.38 |
| To 8 steers at \$16.00 per head.....                  | \$128.00 |          |
| To 250¼ pounds bran at \$20.00 per ton.....           | 2.505    |          |
| To 751¼ pounds wheat at \$20.00 per ton.....          | 7.515    | \$138.02 |
| Balance to the credit of alfalfa hay.....             |          | \$ 70.36 |
| Received for alfalfa hay per ton*.....                |          | \$ 8.59  |
| Lot 4                                                 |          |          |
| By 8 steers, 2356.71 pounds dressed weight at 7c..... |          | \$199.97 |
| To 8 steers at \$16.00 per head.....                  | \$128.00 | \$128.00 |
| Balance to the credit of alfalfa hay.....             |          | \$ 71.97 |
| Received for alfalfa hay per ton*.....                |          | \$ 8.44  |

\*Grama reckoned at the same price as alfalfa.

Table XXI.—Live and Dressed Weight and per cent. of Dressed Weight

STEERS 1902-3

| Lot 1     |             |                |                          | Lot 3.    |             |                |                          |
|-----------|-------------|----------------|--------------------------|-----------|-------------|----------------|--------------------------|
| Steer No. | Live weight | Dressed weight | Per cent. dressed weight | Steer No. | Live weight | Dressed weight | Per cent. dressed weight |
| 1         | 650         | 322            | 49.53                    | 1         | 838         | 412            | 49.16                    |
| 2         | 684         | 338            | 49.41                    | 2         | 774         | 394            | 50.90                    |
| 3         | 732         | 372            | 50.82                    | 3         | 770         | 390            | 50.65                    |
| 4         | 590         | 320            | 54.23                    | 4         | 710         | 356            | 50.14                    |
| 5         | 794         | 410            | 51.63                    | 5         | 692         | 353            | 51.01                    |
| 6         | ...         | 370            | .....                    | 6         | 752         | 415            | 55.18                    |
| 7         | ...         | 365½           | .....                    | 7         | 640         | 346            | 54.06                    |
| 8         | ...         | 386½           | .....                    | 8         | 724         | 372            | 51.38                    |
| Total.... | .....       | 2878           |                          | Total.... | 5900        | 3038           |                          |
| Average   | 690         | 352            | 51.07                    | Average   | 737.5       | 379.7          | 51.40                    |

| Lot 2     |      |       |       | Lot 4     |       |      |       |
|-----------|------|-------|-------|-----------|-------|------|-------|
| 1         | 802  | 410   | 51.12 | 1         | 558   | 270  | 48.38 |
| 2         | 650  | 340   | 52.30 | 2         | 628   | 272  | 43.31 |
| 3         | 806  | 400   | 49.62 | 3         | 836   | 431  | 51.91 |
| 4         | 762  | 380   | 49.86 | 4         | 800   | 430  | 53.75 |
| 5         | 774  | 400   | 51.67 | 5         | 796   | 410  | 51.50 |
| 6         | 734  | 416   | 56.97 | 6         | 766   | 380  | 49.60 |
| 7         | 686  | 358   | 52.18 | 7         | 722   | 360  | 49.86 |
| 8         | 682  | 364   | 53.37 | 8         | 698   | 348  | 49.85 |
| Total.... | 5896 | 3068  | ..... | Total.... | 5804  | 2904 | ..... |
| Average   | 737  | 383.5 | 52.03 | Average   | 725.5 | 363  | 50.03 |

Practically all of the cattle disposed of on the local markets are sold without weighing at so much per head. This method affords little opportunity to determine the per cent. of dressed weight of the different classes. Table XXI gives the live weight, the dressed weight and the per cent. of dressed weight



at the time each steer was slaughtered. The average per cent. of dressed weight is figured on the total weight of each lot except lot 1, which was figured on the first five steers. This was necessary because a caving well near the scales rendered their use unsafe.

It will be seen that the average dressed weight increased with the amount of grain fed. Lot 4, which had no grain dressed 50.03 per cent.; lot 3, which had a light grain ration dressed 51.49 per cent.; and lot 2, which received a fairly heavy grain ration dressed 52.03 per cent. on the average.

#### ACKNOWLEDGMENTS

Mr. J. W. Bouts, Farm Foreman, was in charge of the feeding of the steers and the lambs during the winter of 1901-2, and Mr. H. C. McLallen, Assistant in the Department of Agriculture, was in charge of the feeding during the winter of 1902-3. Acknowledgment, also, is due to Mr. McLallen for valuable assistance in figuring and checking the data contained in the tables and for taking the photographs of the steers.



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**New Mexico College of Agriculture and Mechanic Arts**

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**AGRICULTURAL EXPERIMENT STATION**

**MESILLA PARK, N. M.**

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**NATIVE ORNAMENTAL PLANTS  
OF  
NEW MEXICO**

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BY  
**E. O. WOOTON**

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# NEW MEXICO AGRICULTURAL EXPERIMENT STATION

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and to others as far as the editions printed will allow  
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## **SUMMARY**

1. Introduction suggesting the desirability of planting all kinds of shrubbery to increase the value of the property, for protection, for comfort, privacy, and beauty.

2. Recommending the use of native plants, because they are adapted to our dry soil, dry air, wind, hot days and cold nights, late spring frosts, and intense light.

3. Conditions in the valleys reviewed, with recommendations concerning windbreaks and other protective planting.

4. The conditions surrounding the average stockman's home, with suggestions for its improvement.

5. Notes on methods of obtaining such material.

6. Notes on the particular species of native plants which are of value as ornamentals.

a. Coniferous trees.

b. Deciduous trees.

c. Shrubs.

d. Vines.

e. Herbaceous annuals and perennials.

7. Index of species.

## INTRODUCTION

Bulletin Number 47\* of this Station calls attention to the causes tending to produce instability in our population and hence lack of decorative adornment of the homes in our Territory. There is not the least doubt that these conditions were in existence in the past and that the resulting bad habits still affect our population. But the necessity for semi-nomadic life no longer exists and, with new and better conditions, our population is becoming more permanently attached to our soil and the instinct of home decoration is beginning to be aroused. While the "money making" period of our development is certainly not past, it is to be hoped that the "home making" period has begun.

Little need be said in argument for the increase in beauty which will accrue to our homes if surrounded by well set shrubbery. Much might be said advocating such decoration because of the increased privacy which it affords, when properly arranged, and there can be but little doubt of the value of privacy to the average dweller in town or city.

Much additional comfort in the way of shade and protection from wind, dust, and heat may be obtained for the home by the judicious use of shrubbery. Nor will anyone contradict the statement that the well shaded house, surrounded by lawns adorned with clumps of shrubs and blossoming plants and its porches festooned by vines, will command a higher price than the same house in the same location without its setting of plants.

A farm whose fields are protected by windbreaks and shelter-belts (which will also furnish fence posts and wood) is more valuable than one without these adjuncts. A family, living in a home so protected and embowered and appreciating its surroundings, is sure to have better taste and better standards of living than one not so blest.

All of these arguments lead to the conclusion that it is a wise thing to surround any home with protecting and beautifying plants and flowers. And then the question arises:—What plants shall we use?

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\* "Shade Trees and Other Ornamentals," by Fabián García.

## **A PLEA FOR THE USE OF OUR NATIVE PLANTS**

The conditions necessary for the growth of plants are (1) food upon which they can subsist, both in the soil and in the air; (2) moisture in proper quantity in soil and air; (3) a certain total amount of heat during the growing season, as well as a temperature that is neither too high nor too low; and (4) a favorable amount of light. Different regions upon the earth's surface differ greatly in respect to the degree in which they supply these conditions, and, as a consequence, different localities have native floras which resemble each other in about the same degree as the growing conditions of the localities themselves approximate each other.

The degree to which the growing conditions may be artificially controlled varies considerably. The chemical content, mechanical condition or texture, and moisture content of the soil in any locality may be controlled with comparative ease, if small areas only are to be considered. But the humidity of the atmosphere, the temperature limits, and the light intensity of any region out of doors can be modified but a very small amount.

In an area so large as that of our Territory, almost all kinds of soils may be found, but the best natural soils occur only in the higher mountains where they have been sheltered and enriched by heavy forests. Along the foothills and on the mesas the soil is apt to be more or less coarse and rocky, thus requiring a great deal of water to produce plant growth. Here it is usually free from an excess of the salts of potassium, sodium and calcium which form the dreaded "alkali." This, however, is not always true, since the presence of these salts is in a degree dependent upon the kind of rocks of which the adjacent mountains are composed, as well as to some extent, upon the general topography of the region. In the river valleys, where most of our towns are built, the soil is usually the silt of the river and is apt to be fine grained and poorly aerated, while the underlying stratum is nearly always sand. Alkali is also

very apt to be present in greater or less quantity in such soils.

These generalizations as to the soils of the Territory only show their variable nature and make necessary a careful consideration of the particular soil, in which we wish to grow plants.

Our Territory is all of it relatively high above the sea, its lowest valleys being more than 3,500 feet above that level, while some of the mountains rise considerably above timber line. This elevation, when taken in connection with our geographic position, produces climatic conditions in atmospheric humidity, temperature variations and extremes, and a light intensity that are especially severe on all plant life except that which is particularly adapted to such conditions. The lack of moisture in the air is particularly hard upon plants that are accustomed to a humid atmosphere, since it increases the evaporation from their leaf surfaces to such a degree that they are able with great difficulty to get enough water from the ground to replace that lost by evaporation.

Temperature changes, both diurnal and annual, are extreme with us, because our altitude renders our atmosphere thin and the extreme dryness but accentuates this effect. Objects in direct sunlight are quickly heated to a high temperature, while as soon as the sun is gone, all temperatures drop suddenly and severely. Our growing season is very long and the total quantity of heat received during a season is very great, a fact tending to produce rapid growth and relatively short life in our trees.

Light is a necessity to all self-supporting plants (i. e. not parasitic or saprophytic); they must have light in order to manufacture their food. Very few people seem to appreciate this necessary condition of plant life. But plants must have light in the proper quantity, and this quantity differs fully as much as does the proper quantity of water which they require. Some species will grow only in strong light (i. e. are "light demanding" species) while others will endure only a small amount; still others are known as shade enduring species, they take little or much as the case may be. And among



trees in particular, the young tree may be a shade enduring species while the mature tree may be light demanding. The light conditions, any place in New Mexico outside of the dense coniferous forests of the high mountains, are extremely severe; the direct sunlight is most intense and the reflected light is very strong.

When one takes all these conditions into consideration and remembers just how little they can be artificially modified in the open, the wonder is, not that so *few* of the plants commonly cultivated in the humid regions will grow here, but that so *many* of them are able to adapt themselves to such inhospitable surroundings and thrive.

Now our Territory has a covering of plants which are perfectly adapted to our climate and soil; scanty in places, it is true, but abundant and characteristically beautiful in others. Practically all of these plants are thoroughly adapted to those peculiarities of our climate which we can not control and which are so severe on the commonly cultivated ornamentals, viz: Very dry atmosphere, extreme daily variation in temperature, late spring frosts, very high summer temperature, and very intense light. Besides this some of them are inured to extreme dryness of soil and others will tolerate relatively large quantities of alkali.

It seems to me that probably the most important reason for wishing to cultivate the plants of the humid region in this Territory lies in the fact that we are almost all of us originally from that humid region and wish to reproduce, in the new home, conditions similar to those of the old. The desire is perfectly laudable; but does it not lead us away from our easiest method of ornamenting our homes and grounds? Does it not appear that our native plants are better adapted to the unalterable conditions of this region? Would it not be easier to supply artificially a good soil and a little extra water to plants from our mountains than to do the same thing for eastern plants and at the same time try to protect them from our sun, our frosts, our wind, and our dry atmosphere? Which procedure is the more likely to result favorably?

Then there are situations in which it is desirable to have some vegetation where only a limited supply of water is to be had at any time. In such locations some of the typical arid region plants would be thoroughly at home. While they may not be everything that is desirable, they are certainly much better than none, and no others are able to stand such a severe environment.

To me there is an appeal to "the eternal fitness of things" in our native vegetation. It seems at home, a part of the country, and as thoroughly appropriate and in place as an adobe house is in this sun-blest land of ours. This adaptation to environment is so marked in some of the trees and shrubs that, though flat-leaved and of deciduous ancestry, they are nevertheless evergreen and are thus rendered all the more valuable for ornamental purposes.

Hence I urge, as emphatically as may be, the use of our native plants; those plants which thrive in alkaline soil, which can stand six months of drouth, which do not sunscald and lose their stems and leaves on one side, which are rigid and strong enough to resist our winter and spring winds, and canny enough to keep from getting frost bitten when spring plays fast and loose with us. Give them a fair trial, study their natural adaptations, give them slightly better conditions than they naturally have, and I feel sure they will reward the thoughtful, careful gardener by growing even better than in their native habitats. In order to obtain this end, however, it will be necessary to appreciate the particular beauty of each and study *its* possible improvements. It will be impossible to make them over according to some preconceived ideas of beauty obtained elsewhere.

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### CONDITIONS IN THE VALLEYS

In our Territory there are three or four kinds of places where people make their homes. They build their houses in the open river valleys, either singly on the farms, or in groups, forming towns and cities; or they choose isolated sit-

uations near "water," on the mesas, or in the mountains, for the stockman's ranch. The mining camp is usually in some narrow cañon and is apt to be lacking in permanence.

In the valleys, whether on farms or in the towns, the conditions are more or less similar. Shelter is the thing most desired; shelter from the heat and the light of our summer sun, from the wind and dust, or from the public gaze. To these comforts should be added the pleasure and benefit which come from living in beautiful surroundings and striving to make them even more beautiful.

Most of the valley farm houses and not a few of the homes in the towns are more or less protected and beautified by the use of shrubs and trees. The value of fruit trees and grape vines is fully recognized, but I doubt if the simple money value alone of a proper use of shade trees, windbreaks, shelterbelts, shrubbery, and lawns is properly appreciated. Time spent in making the home more comfortable by protecting it, is not wasted, but is well invested. The hedge and shrubbery which keeps the dust out of the house more than pays for itself in saving floors and furniture, to say nothing of muscle and nervous energy spent in cleaning out the dirt. Bodily comfort counteracts nervous irritation and makes for general sweetness of disposition; and it should be our task to make the home the most comfortable place possible. For this reason alone, if for no other, properly and tastefully arranged shrubbery is one source of comfort and pleasure for the household.

There is no reason why practically any style of horticultural decoration may not be used about our irrigated farm and town houses. Formal gardens, informal planting, hedges, windbreaks, orchards and vineyards, vine covered arbors, summer houses and porches may all be had where water for irrigation is available.

Windbreaks and shelterbelts should be used much more in our cultivated valleys than is now the custom. There is little doubt that one of the worst enemies to our orchards and vineyards is our dry wind. Any means of protecting cultivated

fields, orchards, vineyards, decorative shrubbery, and stock from the effect of these winds will be valuable to the valley farmer, and one of the most available forms of protection is to be found in the windbreak or shelterbelt of native trees.

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### THE RANCH HOUSE\*

What is the average ranch house in New Mexico like? Think of those you know and judge whether each does not belong to one of the following types:

A "dobe" hut of one or two rooms, set out on a sun-blistered flat where bulls paw up clouds of pungent dust, while they bellow challenges at each other. Miles away through quivering air dance the distorted outlines of the cool timbered mountains.

A board shanty at the mouth of some cañon on the edge of a boulder strewn arroyo, with everything about it as inconveniently arranged as well can be.

A one-roomed log cabin with a "lean-to," in a beautiful mountain valley, but with every vestige of the native forest cut away from around the house for fifty or a hundred yards on all sides.

These are by no means the only kinds of ranch houses, but they are by far the commonest. Are these conditions necessary? It can hardly be claimed that they are satisfactory or desirable.

In the very nature of the case the great bulk of our Territory must ever be devoted to stock raising. Enough water falls within its limits to properly irrigate only a relatively small proportion of it, even if all that water were caught and hoarded and applied to irrigation. Such a thing being impossible, and the above statement being true of practically all the high arid region in which our Territory lies, we come back to

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\* As used here the expression "ranch house" is intended to apply merely to the houses of stockmen which are not usually located in the irrigated valleys. The author understands that this is a restricted use of the expression which is not warranted by custom, but is here used for lack of a better term.

our first proposition: i. e. the necessity of stock raising in the Territory. It is the only kind of agricultural work possible on the unirrigated lands.

It is also recognized that, under the present system of handling stock, our Territory is losing a large part of the gain which might be ours if our land laws were so constructed as to give a stockman control of enough land to make a living on. But the law makers had other conditions in view when these laws were made, and as yet nothing has been suggested which will overcome the evil resulting to arid grazing lands.

The author also appreciates how this lack of control, the uncertainty of the returns for labor, the rough character of the work itself, the exposure it entails and irregularity of habits which it engenders, all tend to render the ranch house a mere "permanent camp," where one expects conveniences only a grade better than when on the "round up."

Again comes the question: Are these conditions necessary? The author thinks they are not, and fully believes that the day is not very distant when some of them will be materially improved by legislation favorable to the stockmen, which will give them a more assured "grip" on their ranges, and at the same time render labor less arduous, rough, and irregular, and make the ranch house still more "permanent" in character and less like a camp. Many ranches now possess sufficient permanence to make greater comfort a desideratum, but until the necessity for greater comfort is felt, no attempt to gain it will be made.

Some of the comforts which may be added to the ranch house (depending somewhat upon its location) are coolness and shade, protection from wind and dust, increased privacy, and added beauty, thus raising the mental standards and appreciation of its inmates. They may all of them be had at the cost of a little time and labor expended in the judicious transplanting of native plants which grow, in every case, not far from the ranch house.

- The ranch on the mesa may be protected from dust and have its privacy and beauty materially increased by the use of the

*Yuccas*, sotols, ocotillo, and other shrubs of the mesa; while if a little water can be had, cottonwoods, ash, and soap-berry may be induced to add their shade, and cacti and many low plants will grow and bloom in such surroundings.

In the foothills, the site of the house can usually be selected, so as to take advantage of the shade and beauty of well grown trees. It is much easier to pipe the water some distance to the house in order that the house may be protected and beautified by trees already full grown, than it is to place the house near the water and wait for trees to grow. For the ranch located in the foothills or mountains there is an ever ready source of supply of trees and vines and shrubs to be found in the mountains near by, and the average stockman has abundance of time in which to transplant them.

There are, no doubt, good reasons why the tall, shallow-rooted conifers should be removed from close about the ranch house in the mountains, but the reasons which apply to the large trees certainly do not govern the placing of smaller trees like oaks and maples, and the use of vines and shrubs. Shade may not be so desirable, but beauty and privacy both are, and the care necessary to the production of a beautiful little mountain home has its effect upon the industry, taste, and neatness of the inhabitants.

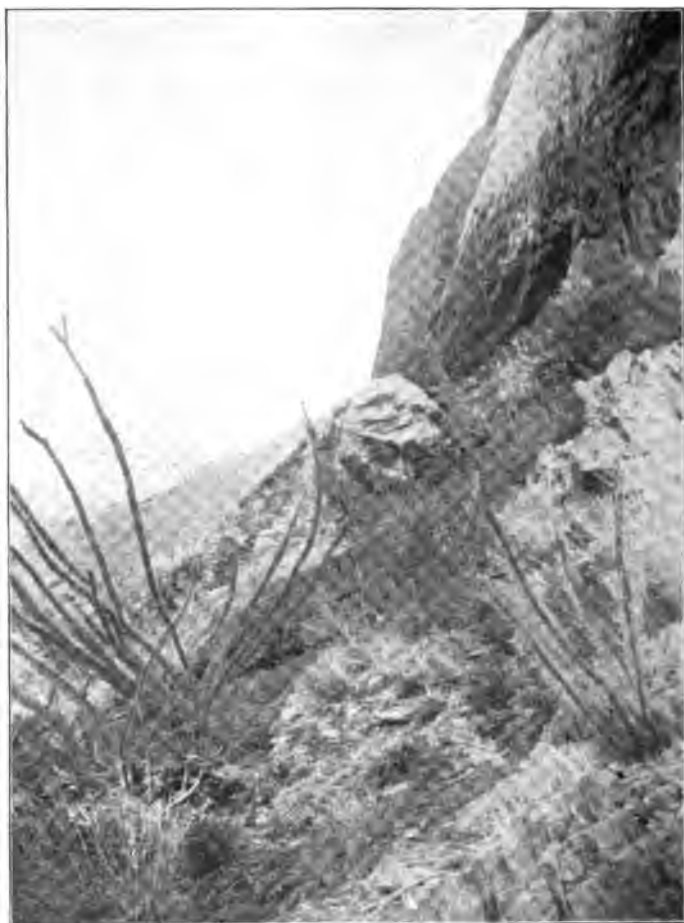
It is hardly possible to say too much on the desirability of permanence in the population of our Territory. The ranchman who comes to stay is the desirable one. He works for the welfare of his township, his county, and his Territory; he is interested in its schools, its churches, its laws, and whenever a man is interested in a thing he does good work for it. He may not do the best thing in every case, but the general result of his energy makes for good in his region. The man who has invested muscle and time and thought and taste in trying to improve the conditions of his home will not be ready to abandon his results for a new place, and when once attached to a place, it is doubtful if any other man would do better in that place.



**Showing Neglected Possibilities.**



**Possibilities Utilized.**



**Candlewood. Ocotillo.**



**The Usual Ranch on the Mesa.  
Remedy: Yuccas, Cacti, Sotol, Etc.**



**METHOD OF HANDLING MATERIAL**

It is not necessary to repeat here the instructions for transplanting dormant plants. Most people who have reached maturity have had some experience, and those who have not may find instructions in nearly any book on agriculture or horticulture, or even in some nurserymen's catalogues. Bulletins No. 40\* and No. 47 of this Station give some details of this character which are particularly applicable to this region.

In this bulletin it has frequently been impossible to refer to a plant by anything except its Latin or scientific name because, so far as the author knows, it has no other. In speaking of the native plants that have no common names, popular descriptions have been given, so far as possible, and some illustrations have been inserted, but these methods will not always succeed in making the reader think of the plant referred to. Different common names are used for the same plant in different parts of the Territory and only a part of the plants here enumerated may be found in any one locality. These conditions will, no doubt, cause some confusion in using this bulletin. Many of the plants here described in their summer condition would be recognized in their dormant state only by a very careful observer. To avoid these difficulties, it is recommended that the would be gardener notice carefully the native plants of his region during the growing season, making particular note of the horticultural possibilities and habits of each, and at the same time examining each with sufficient care to be able to recognize it without leaves or flowers or fruit. When next they are dormant such plants as are selected may be transplanted. Such treatment is, of course, not necessary with any kind of evergreens.

It must be remembered that, *the roots of conifers must never be allowed to dry during the operation of transplanting.* A good way to avoid drying, is to "puddle" them at once, as nurserymen do, by dipping the roots into a thin mud or a mixture containing fresh cow manure and then wrapping them in wet straw or trash which will keep them moist.

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\* "A Southern New Mexico Flower Garden," by F. E. Lester.

Plants which grow in shallow rocky soil are rather difficult to dig because, in such soil, the roots spread widely, and in digging it is hard to avoid cutting off the smaller rootlets with the pick or spade. The moral to this is to get all the roots of the plant that you can.

Plants just transplanted must be watered immediately and the soil compacted sufficiently to bring the wet soil into close contact with the roots. Nor must the soil be allowed to cake and sun-crack later on, else the moisture will evaporate and the plants die. Practically nothing but cacti will bear transplanting into a dry soil without being irrigated at the time of transplanting, and I would irrigate cacti even if it were necessary to carry the water in a bucket.

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## NOTES ON THE NATIVE PLANTS

### CONIFEROUS TREES

While there are a number of species of coniferous trees, or "evergreens" as they are quite frequently called, native in the Territory they are usually restricted to the higher altitudes. Only the **Juniper** (*Juniperus pachyphloea*), the **Cedar** (*J. occidentalis*), and the **Piñon** (*Pinus edulis*), naturally grow at elevations below about 6,000 feet. The two junipers are very slow growers and are never very satisfactory trees, though their power of resisting drouth and heat would recommend them for exposed and dry localities. A single piñon, transplanted into this valley, as a small tree, thirty or more years ago, has made a symmetrical tree about eighteen feet high. *Juniperus scopulorum* is a very graceful juniper which closely resembles the eastern "cedar" (*J. Virginiana*) and grows in our mountains at elevations of about 6,500 to 7,500 feet. Its slender branches are inclined to droop, its berries are small and covered with "bloom," its form is somewhat conical, and it is altogether a handsome tree. It would make a valuable decorative tree, of the rather formal sort, for lawns and door-yards in the cities which are at rather high elevations. The **Blue Spruce** (*Picea Parryana*) and the **White Spruce** (*Picea Engel-*

*manni*) should also be used in similar situations. They generally grow at slightly higher levels, but could, no doubt, be brought down from 500 to 1,000 feet below their natural levels by furnishing them with a small amount of shade and a little more water than naturally falls at such levels. The **Douglas Spruce** or **Oregon Fir** (*Pseudotsuga taxifolia*) and the **Bull Pine** (*Pinus ponderosa scopulorum*) would well repay the care necessary to getting them established. They make, relatively, rapid growth; the young trees ten or a dozen years old from the seed are generally ten to fifteen feet high. In the end they become majestic forest trees. One beautiful forest conifer is the **Balsam** or **White Fir** (*Abies concolor*). It is particularly beautiful when young, and would, no doubt, grow in cultivation in cities which are as high above the sea level as Santa Fe or Las Vegas. In general it might be said that the native conifers grow too slowly and are too restricted as to the level at which they will grow to ever be very popular as shade or decorative trees in the Territory, and only those individuals who are anxious to make their surroundings resemble the natural forest conditions of the region will ever use them. The introduced species of Junipers, Arborvitae, and Cedrus\* will be more popular, because of their more rapid growth and greater adaptability.

To all who would transplant conifers we would say: Be sure to transplant quite small trees.

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### DECIDUOUS TREES

**Cottonwoods.** Three distinct species of cottonwoods are native in the Territory and their use as shade trees is well nigh universal. As trees they have several points in their favor, and number most men among their friends, but occasionally one meets a man who says he would rather have no trees at all than have cottonwoods. His objections are usually matters of personal taste, though he is apt to talk of the dirt due to their "cotton" or the effect of the mistletoe. The first

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\*See Bull. No. 47, this Station, pp. 32, 36, 37, and 39.

of these objections is easily avoided by planting the cuttings taken from the staminate\* or so called "male" trees. The second difficulty necessitates the cutting out of the mistletoe about once a year; if properly watched the parasite never becomes very objectionable.

The best feature of the cottonwoods is their very rapid growth. Five years of proper treatment will generally insure a good sized shade tree, and when once established they require very little attention. As an "all around" shade tree for the streets, roads, and drives there is probably nothing better growing in the Territory. Their symmetrical rounded tops, their glossy leaves ever whispering to the slightest breeze, their glorious golden heads, when the first frosts come, their almost perfect adaptation to the condition of the valleys in which we live, make them most excellent trees to have about our homes.

**The Valley Cottonwood** (*Populus Fremontii* Wislizeni). This is the common tree of the lower irrigable valleys of all the southwestern arid region from the Rio Grande to the Pacific, and forms much the greater part of the "bosques" of the Rio Grande, the Gila and the lower Pecos valleys. Wherever the land is under cultivation, this cottonwood is used more or less as a shade tree, or in a few cases, for windbreaks. It is a particularly rapid grower, and in the valleys where the water table is but a few feet below the surface, these trees

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\* Possibly it would be wise to explain just what is meant by the staminate trees, for the benefit of those who have not studied botany. The cottonwoods belong to that group of plants in which the two organs necessary to the production of seed (i. e. stamens and pistils) are borne upon separate trees. The stamens furnish the pollen, (or yellow fertilizing dust) and after the very simple flowers which contain the stamens cease blooming, the trees bearing them show no further evidence of being concerned in seed production. The troublesome cotton consists of numerous hairs which surround the seeds to assist in their distribution, hence is only produced by the seed bearing or "female" trees. The staminate flowers are reddish or brownish or sometimes a dull yellow, and hang in pendulous spikes which appear on the trees before the leaves. They show no sign of the green berry like balls which contain the seed. The pistillate catkins, however, are green, and each flower consists of little else than a rudimentary ball with the expanded stigma above it. There are fewer flowers on these catkins and they usually appear with the first leaves or a little later.



**PINON.** Grown in the Valley. About 30 years old.



**Acuminate-Leaved Cottonwood, Used as a Windbreak Around a Reservoir.**



**Mountain Cottonwood.**



**Sycamore**

soon get their roots down to the water and do not need to be irrigated. As has already been suggested, it is necessary to protect them, at least in the southern part of the Territory, from attacks of the mistletoe. The tree grows fifty or sixty feet high under favorable conditions, forming a symmetrical rounded head, with gracefully arching branches and is effective for street use. When grown alone and frequently pollarded, as is the too common custom in the Mesilla valley, it is apt to become short and bunchy. The author has seen it used very effectively to produce a high arched open green canopy over a house which was thus rendered most pleasantly cool in the warmest weather. The tree may be recognized by its broadly triangular leaves, which are nearly as broad as they are long.

Another cottonwood which is fully as effective and offers a slightly denser shade is the acuminate leaved cottonwood, (*Populus acuminata*), which has narrowly oval, taper-pointed, and darker green leaves. This tree is used as much or more than the valley cottonwood on the streets of Deming and Silver City. It would, no doubt, grow well in any of the towns and valleys of the Territory where it could be given a limited amount of care and water.

**The Mountain Cottonwood.** (*Populus angustifolia*) grows native along the streams in our mountains at elevations of from 5,500 feet to about 7,500 feet above the sea level. It is an exceedingly graceful tree with rough grayish bark and dark green, glossy, willow-like leaves and makes a very desirable shade tree, especially at the higher levels in the Territory. It has been grown quite successfully at Lincoln, where it is preferred to the valley cottonwood. It is certainly worthy of more general adoption.

**The Quaking Aspen** (*Populus tremuloides*) is really a cottonwood and should be used much more than it is. As shade trees they are not valuable because the top is small and thin, but used in clusters in connection with conifers, their white stems would be as effective as the birch of the eastern states. They probably would grow only at the high levels.

**Willows.** Closely related to the cottonwoods and usually associated with them are the willows. There are a number of species native in the Territory but most of them are but small shrubs bordering the streams and ditch banks.

**The Black Willow** (*Salix nigra*) becomes a tree twenty to thirty feet high in favorable localities and its spreading crown is often broader than it is high. This tree grows readily in sandy soil where the water is near the surface and could be used most effectively for shade and windbreaks about reservoirs or for shelter belts in the lowest of the valley lands or along ditch banks. It is the common willow tree of the river valleys, being almost as abundant in the Gila valley in New Mexico as is the cottonwood.

**The Mountain Ash** (*Fraxinus velutina*) is perhaps as satisfactory a tree for general decorative and shade purposes as grows native in the Territory, and its value is appreciated in the Mesilla valley where it is used quite extensively. The common name is a local one and does not refer to the shrub which ordinarily goes under that name in the eastern and central states (*Sorbus Americana*). It is a true ash. It naturally grows in the rocky cañons and dry water courses of the warmer more barren portions of the mountains, and here it attains a height of thirty to forty feet. The trunk is straight; the bark is a light brownish-gray and quite smooth even in good sized trees; the branches grow obliquely upward with rather a sharp angle and are stiff enough to bear their own weight thus giving the tree a symmetrical head. The foliage is rather pale green, not very dense, appears rather late in spring, and is rarely ever hurt by late frosts. While not as rapid a grower as the valley cottonwood, the mountain ash is a vigorous and healthy tree in cultivation. The mistletoe attacks it but slightly and the winged fruits are never sufficiently abundant to be a nuisance. Young trees may be obtained in the cañons of nearly any of the mountains in southern New Mexico at altitudes below 6,500 feet and are easily transplanted any time when the leaves are off.

**The Box Elder** (*Negundo aceroides*) is also a favorite as a na-



tive shade tree, and it is worthy of the praise it receives. A graceful, round-topped, symmetrical tree of this species forty to fifty feet in height may be produced in a relatively short time if conditions are favorable. The native habitat of the tree is in the lower levels of the Territory, where it is associated with the valley cottonwood, the black willow, the mountain ash and a few other less common trees, in the open irrigated valleys or along streams in the broken country at elevations below 6,500 feet. Here it may be found or it may be grown from seed. Those who are not familiar with it can recognize it by its general similarity to the maples, but its wood is softer and spongier, its leaves are light green and composed of three separate leaflets, and the young growing stems are green. The fruit is of the common winged type of the maples. It requires treatment similar to the valley cottonwood or mountain ash.

**Maples** (*Acer spp.*). There are two native species of maple which grow in the higher mountains (from 6,500 to 9,000 feet) of the Territory but neither are of any particular importance as trees. The red maple (*Acer glabrum*) becomes a low tree twelve to eighteen feet high and may be recognized by its red growing twigs and leaves having three separate leaflets. The other (*A. grandidentatum*) has light gray, almost whitish, smooth, bark, even on the younger limbs, and the usual simple lobed leaves which have coarse blunt teeth and lobes with rounded sinuses between the lobes. It usually forms a large spreading shrub rather than a true tree. What might be done with them in cultivation is hard to tell, though they would probably be useful for variety on large lawns or in parks. They could be grown at the higher elevations in the Territory. Like the cultivated maples, their foliage is generally brilliantly colored just before the leaves fall. If a large lawn or park were to be decorated, a few of them might be used for the sake of their brilliant autumnal foliage alone.

**The Soapberry Tree** (*Sapindus marginatus*) has been introduced into cultivation in a few localities with some success. It is well worth cultivating and will stand the conditions found

in the lower, warmer and drier parts of our Territory. The tree is of medium size with straight trunk, smoothish light brown bark, round head and light green foliage. The leaves are of the compound type something like the walnut, from six inches to a foot in length, but the separate leaflets are narrowly lanceolate in shape, about two inches long, and without any marginal teeth. In the spring these trees bear rather large panicles (four to six inches long) of small dull white flowers, which are followed by a scattering cluster of brownish berries each of which contains a single ellipsoidal brown seed one-fourth of an inch in length. The plants may be grown from the seed, or young trees a foot or two in height may be obtained in the lower parts of the mountain ranges in warm rocky cañons. In its native habitat the tree is of slow growth and relatively small, but in cultivation it grows more rapidly and is a slightly darker green.

**The Walnut or Nogal** (*Juglans rupestris*) is a native tree which deserves more attention in this region. It grows naturally in our mountains at elevations of from 4,500 to 6,500 feet, and is not uncommon in the valleys and "draws" tributary to the Gila river. The tree resembles the black walnut of the Mississippi Valley states in most respects, except that it is generally smaller in size, and the "nuts" are only about half to two-thirds as large as the black walnut. We have not yet raised any of these trees and the author has never yet seen a young tree, hence accurate data as to methods of cultivating them can not be given here; but it is altogether likely that it will be necessary to plant the "nuts" where the tree is expected to grow, as trees of this kind rarely stand transplanting well. It may be advisable to soak the seeds for a time in order to get them to sprout freely.\*

**The Sycamore** (*Platanus Wrightii*) is another native tree that

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\* Timely hints for Farmers No. 50, Arizona Experiment Station. Dec., 1903. Prof. Thornber here recommends that hard seeds be soaked in hot water for a short time, or in luke warm water for several hours. He also recommends "Stratifying" for some hard seeds. This paper should be consulted for accurate data as to temperature of water and time of soaking.



**Valley Cottonwood. Showing habit when not cut back.**



**Black Willow.**



**Live Oak. (Q. Arizonica.)**



**Live Oak. (Q. Oblongifolia.)**

might be used for decorative purposes. It grows naturally in the southwestern part of our Territory, so far as I have seen, only in the foothills of the mountains in the region of the Gila and its tributaries. This tree attains a height of sixty to seventy feet, is not infrequently twenty-four to thirty inches in diameter at the butt, has a wide spreading open head, smooth, flaky, whitish gray bark, and large palmate leaves whose five long acuminate lobes hang downward in a cluster with points almost touching. It may be rather difficult to get into cultivation.

There is a **Wild Mulberry** (*Morus microphylla*) which grows in the drier cañons of the mountains at elevations below 8,000 feet that might be introduced into cultivation quite readily, but it is doubtful whether it would have any advantage over the Russian Mulberry\*, unless it be in the absence of fruit.

The **Hackberry** of this region (*Celtis reticulata*) is a spreading tree which might be used very profitably and effectively in certain locations. It naturally grows on the drier, warmer slopes of our rougher mountains and in the arroyos at their bases. It retains the smallish reticulated leaves until quite late in the fall, and is one of the freshest and greenest of the green things to be seen in the early spring. Its leaves become quite dark green in the summer and the shade which the tree produces is denser than that of any of the trees which naturally grow with it. The fruit of this tree is much like the hackberry of the eastern states, except that when ripe it is tan colored, but it is of no value. This tree is particularly adapted to dry rocky soils which are very warm. It thrives on a very small amount of water and in situations very unfavorable for most other trees.

The **Oaks** of New Mexico are more numerous than is generally supposed and three or four of them might be used very effectively for decorative purposes. They are generally known as scrub-oak, including several species of evergreen trees having low widely spreading crowns; the white oaks, with dark deeply lobed deciduous leaves; the black oak, with

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\* See Bulletin No. 47 of this Station, p. 22.

rather rough bark and glossy spiny leaves; and the silver leaved oak, which has narrowly oblong leaves that are glossy on the upper surface and white and wooly beneath. The evergreen species usually have relatively small bluish green leaves which are either smooth along the margin or have a few more or less spiny teeth. The deciduous leaved oaks have larger (three to five inches long) leaves which have several rounded or incised lobes and are chrome-green in color.

**The Silver-Leaved Oak** (*Quercus hypoleuca*) would be as valuable in cultivation as any of the native oaks, and it is certainly beautiful enough, as a mature tree to pay for considerable work and trouble to get it started. In its native habitat it may be seen in the form of a good sized shrub forming clumps, and also as separate trees of considerable size. In either condition it is particularly attractive because of its peculiar foliage which is evergreen.

**The Black Oak** of the southwest (*Quercus Emoryi*) is a small tree with very dark rough bark and glossy evergreen leaves. Its branches are usually relatively slender and, where supplied with plenty of water, the tree is rather a free grower and is quite graceful. It grows naturally at elevations of from 4,500 to 6,000 feet in the drier parts of the mountains of the southwestern part of our Territory. It will stand almost any degree of dryness.

**Scrub Oaks.** Several species are included under this general name, some of which are evergreen and some are deciduous. None of them reach any considerable size and are of no particular horticultural value, unless they might be used as hedge plants.

**Live Oaks.** This name is indiscriminately applied to several low, round-topped trees of the warm, dry hillsides in the juniper zone. They are of very slow growth, so slow that they would be difficult to grow for shade trees. They have gray, rather smooth bark and small bluish green leaves that are rarely over two and one-half inches long, have a few stiff teeth, and are thick and tough. They are sufficiently picturesque to warrant their retention if found already grown, instead of

cutting them down as is usually done, and they are so hardy in their native habitat that they will submit to almost any treatment.

**The White Oaks** also comprise several nearly related deciduous-leaved species found in our higher mountains where they obtain considerable moisture. They might be used effectively at the higher elevations in the Territory. They would undoubtedly grow at much lower elevations than where they grow naturally, if they were given plenty of water. These species drop their leaves during the winter season. Their leaves are relatively large (three to five inches), deeply lobed, or incised, bright chrome green, and relatively thin.

**The Alder** (*Alnus acuminata*) is a tree found growing along our mountain streams which would be particularly beautiful if it could be brought into cultivation. It reaches a height of fifty to sixty feet, has smooth dark gray bark, branches which rise upward and arch over, dark green leaves which resemble the beech leaf somewhat, and small cone-like fruit. The tree grows freely, associated with the mountain ash, black willow, cottonwood and box elder and would probably lend itself readily to cultivation. It can probably be reproduced from seed, but it may be necessary to plant young trees obtained in the mountains.

**The Wild Cherry** (*Prunus Capollin*) of the lower levels in the drier mountains makes a very attractive tree with its dark smooth bark, glossy leaves, and pendant racemes of white blossoms. It would no doubt lend itself readily to cultivation and would be well worth any trouble so incurred. In its native habitat, it is one of the most beautiful of the trees of the Territory and one of the most conspicuous of the green things which beautify the mountain cañons in the spring. Its fruit would attract the birds. It would be necessary to protect it from the ravages of the caterpillars which usually destroy the first crop of leaves. This might easily be done by using a torch upon the young caterpillars as they begin to form their web.

## SHRUBS

Notwithstanding the apparent paucity of vegetation of our region there are a number of shrubs which have been or might be introduced into cultivation and which would amply reward all efforts to induce them to grow. Part of these shrubs attain some size and grow naturally at rather high altitudes in the mountains, while others are true desert inhabitants and, with few exceptions do not reach a height of more than four or five feet. Those of the mountain sides are mostly deciduous leaved and would need to be supplied with good soil and plenty of water, while those from the mesas will endure almost any degree of drouth and thrive in almost any kind of soil. Most of the latter class retain their leaves from year to year, and for this reason are all the better adapted to certain kinds of uses.

**Syringa** or **Mock Orange** (*Philadelphus spp.*) There are three species of this shrub to be found growing in the mountains at elevations of from 6,000 to 9,000 feet. They all have the showy white flowers of the cultivated species. *P. argyrocalyx* grows to a height of eight or ten feet and produces numerous flowers one to one and a half inches in diameter that have a silvery-white hairy calyx; its leaves are oval and about an inch long, silky hairy beneath and smooth along the margin.

*P. microphyllus* resembles this species tolerably closely, while *P. serpyllifolius* is a smaller bush with much smaller leaves, and flowers about half the size of those described.

Closely related to the above and resembling them somewhat is another shrub of our barren mountains. It is without a common name so far as I have been able to learn: its scientific name is *Fendlera rupicola*, being named (generically) after August Fendler who was one of the first botanical collectors in the Territory. The blossoms are about an inch in diameter, with four pink tinged white petals. The leaves are small and narrow, rarely over an inch long and one-fourth as wide. The shrub is not infrequently six or seven feet high and flowers profusely in May, though the blooming season may be delayed until later in the summer.





**Black Oak.**



**Walnut. Nogal.**



**Soapberry Tree.**



**Candalabrum Cactus La Cholla.**

Another relative of the preceding species is a shrub found in the high mountains along streams, called *Edwinia Americana*. All of the shrubs, so far named, are related to the cultivated hydrangeas, and this one, by its shreddy bark, its opposite, rather large, elliptical, scalloped leaves, and pyramidal panicle of white flowers, suggests the hydrangeas rather strongly. At elevations of 10,000 feet it is usually from two to four feet high; but at lower elevations, where it gets plenty of water, I have seen bushes six to seven feet high. It is quite a pretty shrub when well grown and in full bloom.

*Holodiscus australis* is the botanical name of a rather large shrub which I have heard called Wild Crape Myrtle, but I do not believe this name is extensively used. The shrub frequently reaches the height of ten feet and produces numerous flat panicles of small cream colored flowers. It belongs in the rose family and the flower clusters quite strongly resemble those of the cultivated *Spireas* to which it is nearly related. It lives in the higher mountains (7,000 to 9,000 feet) among the pines and spruces, but does not seek the shade; hence it would doubtless grow in the open at lower levels if supplied with a good soil and plenty of water. It is well worth cultivating.

**New Mexican Black Locust** (*Robinia Neo-Mexicana*). Most of us who have spent any time in the mountains in the summer have seen this plant, which frequently attains the size of a small tree. It closely resembles the ordinary black locust but it is a more scraggy grower and its flowers are larger and of a beautiful rose pink color. Well up in the mountains it frequently grows in tolerably large groups which have a characteristic appearance. It has been successfully transplanted at this Station, but it is a slow grower and has a poor form. Grown with other shrubs it would give variety, but it is not satisfactory for much else.

**Algerita\***, or **Barberry** (*Berberis haematocarpa*). This is an

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\* I can find no authority for this spelling, which is a mixture of Spanish and English. I have heard the word only in the mouths of Americans and think it may be a corruption of a Spanish word. It certainly is not Spanish as it stands.

evergreen shrub found growing naturally at elevations from 5,000 to 6,000 feet in the southern parts of the Territory on dry hillsides, and in the "draws" in the foothills of the mountains. It reaches a height of eight to ten feet in favorable locations and forms a bush four or five feet in diameter. The leaves are compound, having three, five and sometimes seven thick, smooth, leathery leaflets, each of which has a few stiff spiny teeth along the margin. They are suggestive of the holly leaves. The bark is stringy and brown; the wood is a bright yellow color and rather tough; the flowers are small, light yellow, and borne in clusters about three inches long, blooming in May and June; the fruits are bright red berries, a little larger than currants, and are ripe in August. In some parts of the Territory the berries, which are borne in abundance, are used for making a jelly, which is quite good. This shrub should grow very well in cultivation because it grows naturally in conditions which are more severe than those supplied in any garden, and it would amply reward the gardener for his trouble. It would be necessary to transplant small bushes. *Berberis Fremontii* is a shrub which closely resembles the Algerita, except that its fruit is dark blue and dry. It grows in similar situations further west and north, reaching New Mexico only along the western side. *Berberis Fendleri* is a spiny shrub, three or four feet high, with simple obovate leaves and golden yellow flowers, first collected on Santa Fe creek. It would probably come into cultivation readily.

**The Desert Willow or Mimbres** (*Chilopsis linearis*) has already been brought into cultivation and its nursery varieties are to be had of progressive nurserymen. The native species reaches the size of a tolerably large branching tree in the southwestern part of the Territory. It generally grows in the form of a loose straggling bush with several stems rising in a cluster from the root, and may be found in most of the rocky arroyos leading from the mountains. Its branches are slender, graceful, smooth and willow-like, and its narrow leaves add to this resemblance; but its flowers appear in rather large clusters of whitish blooms at the ends of the

stems. They are somewhat similar in shape to catalpa blossoms but have rose purple blotches and spots on the corolla. The fruit is a slender cylindrical pod about six inches long which also resembles the pod of the catalpa. The desert willow may be pruned as a small tree: in this form or as a bush, it is a very effective ornament in early June when it is in full bloom. Rooted plants are easily transplanted from the arroyos.

Associated with the desert willow is a rosaceous plant sometimes called Poñel by the Mexicans, (its botanical name is *Fallugia paradoxa*), which would be tolerably valuable in cultivation. It is a shrub that reaches a height of six or eight feet in favorable localities. It has small dissected leaves which are covered with yellowish hair on the under surface; its flowers are bright white and about the size of a pear blossom, which they resemble slightly, but are borne singly on slender stems; they are followed by spherical heads of plumose, long-tailed seed-pods which are greenish with a reddish tinge. These plants are easy to transplant and will stand large amounts of sunlight and must have a moderate amount of water.

Certainly one of the most beautiful of our native shrubs is *Garrya Wrightii*, a bush which is not infrequently ten or even twelve feet high. It grows in the rocky cañons of the mountains at elevations under 6,500 feet. The leaves are elliptical, entire, about one to two inches long, and bright green; and, what is better, they remain green all the year. The flowers are inconspicuous whitish blossoms and are followed by slender clusters of dry, blue-black berries. So far, we have not succeeded in getting this plant into cultivation but hope to make it grow. A hedge of such plants would be a very valuable windbreak in the spring, as well as add much to the appearance of a yard or garden.

**Lemita. Three-Leaved Sumac.** (*Rhus trilobata*). This is a many-stemmed shrub which grows upon our dry mesas, in the rocky arroyos in the mountains, and on our ditch banks in the valley. It has been used to some extent in cultivation in

this valley, and grows luxuriantly when given a moderate amount of water. It produces long slender stems which are inclined to trail. The leaves are compound, having three obovate, scalloped leaflets one to two inches long; the inconspicuous yellow flowers appear before the leaves in the spring; the fruit is a cluster of small hairy, orange-scarlet berries each of which is but a seed with a small amount of pulp attached and surrounded by the dry bladdery skin. Its leaves are deciduous,

A nearly related species is *Rhus virens*, with evergreen compound leaves having seven to nine oblong, thickish, shining leaflets. It forms a small branching shrub four or five feet high.

**The Golden Currant or Buffalo Currant** (*Ribes aureum*) is a very desirable shrub for cultivation and one whose beauties have long been appreciated. It grows wild in our mountains and along some of the streams. It becomes a rounded bush five feet or more high, and in the early spring is covered with beautiful, yellow, tubular flowers about one inch long and most pleasantly spicy fragrant. The berry is at first yellow but turns black when ripe. The shrub is easily transplanted and may be divided.

**Roses** (*Rosa spp.*). There are several species of wild roses in the Territory which have been more or less cultivated. The commonest is *Rosa Fendleri* of the higher mountains, with its delicate pink flowers and slender, graceful, dark-red stems. It grows well in cultivation in this valley. *Rosa stellata* has about the largest blossoms of any of the wild roses, and they are deep crimson in color, but as yet we have not succeeded in getting it to do well in cultivation.

**Garrambullo** (*Lycium Torreya*). This is a relative of the eastern "Matrimony Vine," and becomes a low thick-set shrub. Its numerous, stiff, spreading spine-like branches form an intricate net-work of stems. The leaves are small, thickish and fascicled. The flowers are small, tubular, greenish purple, and followed by small scarlet tomato-like berries which the Mexican children seem to relish. The leaves open

early in the spring, and the plant needs relatively little water. It is common in the arroyos and on the sand hills of the valley. As a hedge plant it would be a decided success.

In the northern and eastern parts of the Territory and adjoining states, there grows a shrubby Morning Glory (*Ipomoea leptophylla*) which becomes from two to four feet high, and bears numerous large, purplish-pink flowers that look like the common morning glories. The plant has a very large tuberous root and narrow leaves two to four inches long, while the flowers are about three inches long. It would probably grow readily from seed.

There are two perennial plants found growing upon our driest mesas which are without doubt the colder, arid land equivalents of the palms and their allies, found in the tropics. The Mexican people have recognized the resemblance and have called the broader leaved one *La Palma*, and the narrow leaved species *La Palmilla*; and the names are well applied. We call the larger plant the Spanish Bayonet, though the Latin generic name of *Yucca* is getting to be more commonly used. The narrow leaved species, being more useful and somewhat less dangerous, has received the less euphonious name of Soapweed, because its roots make a good soap.

Most people see very little of value in these plants, but they, with others of their associates, offer a number of horticultural possibilities. The one quality of paramount importance which these plants possess is their perfect adaptation to arid conditions, which must be endured in many places where it is very desirable to have some vegetation. Attention has already been called to the appearance of many of the cattle ranches of the Territory, and there is no doubt that the owners of many of these ranches excuse themselves from any exertion towards adding vegetation to their surroundings by saying that nothing will grow on our mesas. These two plants (as well as some others) are living refutations of their excuses. Not only they will grow, but they will grow well, and what is better still, plants of these species of any size and age may be transplanted with but little danger of loss. When it is remembered

that a "Spanish Bayonet" or "Soapweed" eight or ten feet high, is probably as old as a cottonwood a foot in diameter, it seems strange that so few of these *Yuccas* die when transplanted. And they are to be had for the digging, any place in the southern part of our Territory.

Another advantage possessed by these plants, is that they are always in full leaf and green; and their wax-like blossoms, when they come are most beautiful. For massing, for hedges, for formal bedding plants, and for low windbreaks they are most effective. A hedge or windbreak six feet high may be had fully grown for the planting, and such a hedge will give protection to other less vigorous and yet valuable smaller plants. Without doubt there are many places where the *Yuccas* may be used effectively for beauty and comfort, but they will not become large shade-casting trees, though they may reach a height of eighteen or twenty feet. However, we should recognize their usefulness within their limits and utilize them in locations where practically nothing else will grow.

**Spanish Bayonet, Spanish Dagger, La Palma** (*Yucca macrocarpa*). This is the broad and stiff leaved species which is common on the mesas in the southern part of the Territory. Ordinarily it has a straight stem six to eight inches in diameter and four to eight feet high with a head of stiff spreading leaves about four feet in diameter at the top. Under favorable conditions this plant will reach a height of eighteen or twenty feet. The stem is usually simple, but sometimes it branches either at the base or some distance from the ground. When it branches from the ground it not infrequently makes beautiful formal bedding plants, producing a mass of radiating green leaves which is almost geometrically perfect. This plant is particularly easy to transplant, because its under-ground stem is rarely over eighteen inches long, and its roots are small and fibrous, thus rendering the digging relatively easy. A very little water in excess of the rainfall during the first season after transplanting will prevent its dying and then it can take care of itself. The loss in transplanting large plants of this species will not average two per cent.



**Soapweed, La Palmilla, Amole** (*Yucca radiosa*). This is the tall narrow leaved species of *Yucca*, and in my opinion is the more beautiful plant of the two. Its leaves are slender (half an inch wide or less), flexible, and very numerous; its flower-stalk is much taller, its blooms make a better showing, and its stem is more often branched. For hedges and windbreaks it is better because it has thicker heads. But its tap root extends below the surface from four to six feet, and it is often necessary to cut it off in digging the plants, thus causing a greater percentage of loss. Of fifty-two plants which I have transplanted, twenty-five per cent. of them died; these plants were put in a soil where there was much more alkali than that in which they naturally grow and were generally subjected to worse treatment than they ordinarily get; hence a part of the loss may be due to these causes.

**Sotol** (*Dasyllirion Wheeleri*). This is a near relative of the *Yuccas* and is usually found more or less closely associated with them. Its stem is usually short (less than four feet) and crowned with a head of numerous, flat, radiating, strap-shaped, flexible leaves whose margins have many hooked teeth. These plants usually grow among the rocks and are hard to dig; young plants transplant the more readily. They are valuable for formal masses of bedding plants, or bedding plants, or against a hedge row. The bloom stalk is frequently eight feet high; the flowers are small and of two kinds (staminate and pistillate) borne on different plants.

**Bear Grass** (*Nolina spp.*). Plants somewhat closely resembling the last. The leaves, however, are stiffer and thicker (sometimes triangular in cross section) and without the teeth, though frequently rough. The flowers are small and white. borne in a central panicle varying in height (as does the plant) with the species. They might be used effectively any place where the Sotol would grow.

**Candlewood, Ocotillo** (*Fouquiera splendens*). This spiny shrub is frequently used for fences by the Mexicans and sometimes as a guard for young shade trees. In a formal bed associated with Cacti, Sotol, Bear Grass, and *Yuccas* it adds much to the



**Sotol.**



**La Palmilla at Home.**

until the summer is well advanced. Besides the quality and general adaptiveness, vines are especially valuable because of their rapidity of growth: they produce their favorable results in a very short time after planting. This is a thoroughly satisfying quality because it is so tiresome to think of the long years that must elapse before the small trees will amount to anything; particularly tiresome if one needs shade badly. Under such conditions it is well to plant vines, at least for temporary results, until the trees can grow.

**Virginia Creeper** (*Parthenocissus quinquefolia*) is referred to\* as one of our most valuable vines and recommended for use. The fact that it is such a satisfactory plant in cultivation here is rather a strong argument in support of the use of our native flora, since this species is native in our mountains. It may be simply because of the general adaptability of this widely distributed species, but at any rate, it would suggest the wisdom of trying others of our native vines and shrubs. The details of the methods of cultivation may be found in the bulletin referred to. It may be used practically any place where a vine will grow and it is especially rapid and vigorous. The more water it receives the more rapidly it grows, but absolute lack of water in the middle of the summer does not kill it; it merely stops growing vigorously and seems to wait for the water.

**Clematis.** There are several native species of *Clematis* that thrive well in the Territory and it is likely that most species of the genus could be grown here satisfactorily. *Clematis ligusticifolia* is the species which inhabits the ditch banks in most of our valleys, though not confined to such locations. It has large clusters of white flowers each of which is about an inch in diameter, and is followed by a head of feathery tailed seed pods. The leaves are compound and the vine climbs by twisting the small stems of the separate leaflets around the smaller parts of the support provided, whether it be dead or living tree or the lattice work of a porch. This vine is very vigorous, and while it will endure very adverse conditions

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\* Bulletin No. 47 of this Station, p. 48.

without dying, it appreciates and rewards a gardener's care. *Clematis Drummondii* is a near relative of the preceding species, which lives upon the mesas and in the foothills of our drier mountains. Its flowers are small and more inconspicuous, the feathery seed pods are longer tailed and less numerous, and the leaves are smaller. Altogether it is not as attractive a plant, though it will no doubt stand greater dryness in the soil. *Clematis Bigelovii* is a species with single flowers on long peduncles; the sepals are maroon-colored, thick and leathery and white-hairy within. The compound leaves have oval entire leaflets mostly, though some of them are deeply lobed; all are smooth and veiny. This is a vigorous vine, well worth cultivating, which grows in the mountains at elevations of about 5,500 feet. *Clematis occidentalis* of the northern part of the Territory would probably do well in cultivation while *C. orientalis* has become to a degree naturalized at Las Vegas.\* All of these species of the *Clematis* have perennial roots which are easily divided and transplanted. The first named species grows readily from layers and would probably do well from cuttings. They are all quite hardy, though *C. Bigelovii* would stand less drouth than some of the others; none of them will winter-kill in the Territory.

**Hop Vine** (*Homulus Lupulus Neo-Mexicanus*). The New Mexico variety of the hop vine is the one found growing along the creeks of our high mountains at elevations of from 6,000 to 8,000 feet altitude. It is a root perennial but slightly different from the cultivated species and may be grown readily from the divided roots. The vine is herbaceous, persisting for but one season, but it is an exceedingly rapid grower. It will cover a tall trellis before the middle of the summer.† The roots to start these vines may be found growing wild in almost any of our mountains, or they possibly might be started from the seed. Transplanting the roots would generally be the most satisfactory way.

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\* Ckll. in Science X n. s. p. 898. "An Alien Clematis in New Mexico."

† See Bulletin No. 47 this Station, p. 46.

**Wild Grapes** (*Vitis spp.*). Any of the native grape vines would grow with ordinary care under cultivation and they are particularly beautiful vines for ornamental purposes. Their glossy green leaves furnish a very dense shade, and the perfume of their blossoms is of that peculiar pleasant kind which seems to be a kind of evanescent nasal beverage that does not cloy. Smelling the flowers rarely gives the effect; it is the atmosphere some little distance from them that bears the perfume whence the most delicate and delicious drafts may be obtained. For use over arbors or trellises, over dead stumps of trees, or on unsightly buildings there is hardly a native vine which would make a more beautiful covering. Transplanting the roots would be the sure way to get them into cultivation, though it is probable that cuttings would grow readily.

**Wild Honey-Suckle** (*Lonicera albiflora*) This is a slow growing vine, or sometimes it assumes almost the form of a low shrub (*L. dumosa*) that grows in our mountains. The leaves are oval, about an inch long and covered with a "bloom;" those of the shrubby plant are generally soft hairy on the lower surface. The upper pair of leaves is united at the base forming a cup in which is borne the small cluster of odorless whitish flowers. The bark on the younger stems is inclined to be shreddy. The fruit is a small berry. This honey-suckle would no doubt come into cultivation readily and would probably grow more freely thus than in its natural habitat, since it lives usually on the dry rocky hillsides where plant growth is most difficult.

**Maurandia Vine** (*Maurandia Wislizeni*). Perhaps the most valuable annual for our dry hot locations is the above named vine which grows wild clambering over low bushes on our sand hills and mesas. It may be recognized by its leaves, which are somewhat like arrow-heads with flaring bases (hastate), about one to one and a half inches long, and its tubular light blue flowers. It may be grown readily from the seeds, which should be planted in September, and the young seedlings will live through the winter without freezing. Our

hot summer sun has no terrors for this vine nor does dry weather daunt it; it grows on to the end of the season when it produces abundance of seed. I have succeeded in transplanting seedlings in the winter, but this is rather hard to do as the tap root is quite long and the young rootlets are near the tip of it.

*Philabertella cynanchoides* is the botanical name of what might possibly be called a vine milk weed. It has narrowly heart shaped leaves, less than two inches long, and small clusters (umbels) of whitish clove-scented flowers which closely resemble those of the milk weed. This plant also has milky sap. It grows readily along our ditches and streams at the lower levels rising from a perennial root, which could be transplanted with little difficulty. For a low climber this vine would be very satisfactory and its sweet scented flowers would be desirable in any garden.

**Morning Glory** (*Ipomæa Mexicana*). It is but necessary to call attention to the ornamental possibilities of our native morning glory which grows readily from seed. As a field weed, it is a nuisance, but as a vine for trellises and the like, it is decidedly valuable. There is another closely related vine (*Quamoclit coccinea hederacea*) growing in our mountains at low elevations which has slender tubular scarlet flowers that resemble the cypress blossom.

The cucumber or melon family furnish three or four vines which might be used in cultivation. One of them the Melon Loco (*Apodanthera undulata*) is a coarse, rough, creeping vine with circular crisped leaves, three or four inches in diameter and gourd-like fruit. It has a thick perennial root and will stand any amount of drouth. It would be well grown with Cacti. It is propagated readily by seeds or transplanting the roots. *Ibervillea tripartita* is a small vine with dissected mottled dark and light green leaves and small scarlet tomato-like berries, which grows among the mesquite bushes on our mesas and which would be an addition to a bed of arid land plants. It could be propagated from seeds. The One-Seeded Bur Cucumber (*Sicyos spp.*) is a rapid growing vine of our high



**La Palmilla and Vines Banked Against a Fence.**



**Clematis and Maurandia Covering a Wire Fence.**



**Sacaton. Seven Feet High.**



**Creosote Bush. Hediondilla.**



mountains, with five-angled, thin, yellowish-green leaves and inconspicuous yellow flowers. The vine is very delicate and climbs by means of tendrils. It could be grown in damp soil and somewhat sheltered places, from seed.

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#### HERBACEOUS ANNUALS AND PERENNIALS

Besides the plants already enumerated there are a number of smaller herbaceous annuals and perennials which might be cultivated with profit, especially in gardens where there is but a moderate supply of water available. But only a few of the more prominent ones need be mentioned here.

Of those taken from the mountains (and they need as much water as ordinary cultivated plants) the Columbine (*Aquilegia spp.*) of which there are three species growing native in the Territory, is very easily cultivated. There are several species of Larkspur (*Delphinium*) which will also do well in cultivation. Several species of *Polemonium*, both yellow and blue would be valuable additions to any garden, while *Pentstemons* and *Gilias*, white and blue, and various shades of red, and *Phlox* of two or three species are to be found in the mountains. A species of Lady's slipper (*Cypripedium Veganum*) has been recommended for cultivation.\*

Of the plants which live in the drier localities and which will grow on practically any soil, not excepting a sand-bed, might be mentioned the *Abronias* (three species) which resemble somewhat the garden verbenas and are very fragrant; the *Datura* with its large, funnel-shaped, purplish-tinged, white blossoms which are borne so profusely and are so sweet; the various *Asters*, both white and purple; the wild *Zinnias*; the *Baileya* with its double yellow flowers and white-hairy leaves and stems; the beautiful pink-flowered *Polypteris*, besides a host of others which cannot be allowed space here.

There are three or four native grasses which might be used effectively in clumps for decorative purposes, especially if placed before dark green backgrounds, such as may be obtain-

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\* Prof. T. D. A. Cockrell tells me that this plant has been successfully brought into cultivation by Mrs. Joshua Reynolds of Las Vegas.

ed by massing evergreens. **Saccaton** (*Sporobolus Wrightii*) is a large grass reaching a height of five or six feet in favorable situations and having a widely spreading graceful panicle. It forms clumps two to three feet in diameter. **Bunch Grass** (*Sporobolus airoides*) is a smaller, though very similar grass well adapted to dry alkaline soils; it grows about two and one-half to three feet high. *Muhlenbergia distichophylla* is a grass of our drier mountains which suggests a small pampas grass and would be very decorative. **Carrizo** (*Phragmites phragmites*). This is a cane-like grass which lives naturally only in moist soils. It grows about six or eight feet high, has broad leaves and a spreading plume-like panicle eight or ten inches long. This common name is also applied to a very nearly related introduced grass (*Arundo donax*)\* which is more valuable than the native species for several reasons.

A good sod grass is a desideratum in our Territory, especially in the lower and warmer parts. None of the native grasses promise to supply this demand and at present nothing better than the Bermuda grass has been found. It has several drawbacks, and, like the cottonwood, a number of people have no use for it, but for arid conditions where a small amount of *clear* water can be supplied, a number of its qualities recommend it strongly.

At some of the higher levels blue grass has been induced to grow very well. In such locations the sod grass question has been solved.

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\* See Bulletin No. 47 this Station, p. 49.

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## BULLETIN NO. 52

SEPTEMBER 1904

New Mexico College of Agriculture and Mechanic Arts

AGRICULTURAL EXPERIMENT STATION

MESILLA PARK, N. M.



Gigantic Gibraltar Onions—an excellent variety. Seed planted Oct. 3, 1903; transplanted March 12, 1904; harvested August 27, 1904.

# ONION CULTURE

BY

FABIÁN GARCÍA

SANTA FÉ, N. M.:  
NEW MEXICAN PRINTING COMPANY,  
1904.

# NEW MEXICO AGRICULTURAL EXPERIMENT STATION

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The Bulletins of this Station will be mailed free to Citizens of New Mexico  
and to others as far as the editions printed will allow  
on application to the Director

## ONION CULTURE\*

### Introduction

Onions can be grown successfully in many parts of New Mexico. Some sections seem to be particularly adapted to the growing of certain varieties. In the Rio Grande valley, for example, the old "El Paso" onion, which is of the Spanish type, grows to perfection, and in the past this valley, especially the lower portion, has had quite a reputation for growing this variety. Owing to the great difference in altitude and climatic conditions throughout the Territory, there is no doubt that the methods of treatment of the crop in the lower and warmer valleys is somewhat different from those employed in the mountains and more elevated regions. Perhaps one of the chief differences is in regard to the time of sowing the seed, which is, usually done later in the season in the higher and cooler sections.

It appears that there is a general lack of interest in onion growing, and every indication points to the cultivation of a less acreage than formerly. Even the famous "El Paso" variety is exceedingly hard to secure. The production is so small that a large per cent. of the onions consumed, even in the best onion growing districts of the Territory, are brought in from other states. In many of our towns, California onions usually retail for five cents per pound throughout the year. It is to be regretted that such a state of affairs should exist, especially when fine onions can be grown in the Territory. If enough onions cannot be grown for shipping, at least a sufficient quantity should be grown for home consumption.

The onion would make a good crop for the gardener or the small farmer to grow. Of course, it should be kept in mind that onions are expensive to raise, but as a rule they are among the best paying crops. It should also be understood by the beginner in onion-growing that raising this crop, in

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\* A Spanish edition of this Bulletin has also been issued.

order to get the best results, requires close attention and much hard work.

During the past three seasons, the Experiment Station has been conducting experiments in onion-growing on a small scale. The principal features of the investigations have been as follows:—testing of varieties, method of culture, and the keeping qualities of the varieties grown, and ascertaining cost of production and yield.

#### **Soil**

The character of the soil on which onions are grown in this section has a great deal to do with the yield. If the onions are grown on a hard adobe soil which packs and bakes considerably after being irrigated, the bulbs will not develop as large nor as evenly as when grown in a light, rich soil. As a rule, a soil that becomes hard and packs around the bulbs tends to reduce the size of the bulbs and the yield. The onion, which is a shallow feeder, needs a light, rich, moist soil; one that is loose and has plenty of available plant food close to the surface. If the soil is thin or poor, even if it is light, the yield will be low.

#### **“The Old Method” of Seeding**

This applies to the method of sowing the seed in the field. If the onion crop is grown by this method, the ground must be thoroughly prepared for the reception of the seed. Since the soils—even the lighter ones of this Valley—have a tendency to run together and pack when irrigated, it is of the utmost importance to prepare a good seed-bed. The soil frequently packs so much, after being watered a few times to produce germination, that the seeds come up slowly and unevenly. The difficulty may be obviated to a certain degree by drilling the seed on the sides of ridges and irrigating in the furrows. It is necessary, however, to be careful that the water does not cover the seeds on the ridges, for if it does they will have about as hard a time coming through as when grown in plats. While the ridge system of starting the plants, as a rule, gives better germination, it is more ex-



pensive than level culture. The distance between the rows depends on the method of cultivation and irrigation. If the furrow and ridge system is to be followed, the ridges are plowed up not less than three feet apart and then leveled to about ten inches on top. Two rows, four or five inches apart, are drilled in on each ridge. If hand culture and the flooding system of irrigation is practiced, the rows are planted fifteen inches apart; but, if the field is to be cultivated by horse, thirty inches is about the minimum distance between the rows. The seed is sown about one inch deep with a hand drill, and irrigated immediately after to start germination. Ordinarily it will take four to six pounds of seed to the acre, when sown in the field. It is well to use a liberal supply of seed since it is more likely that a good stand will be secured.

While sowing the seed out in the field is the old and a very common way of growing onions, it does not seem to be as satisfactory with our conditions as the so-called "New Method," which we have found preferable. As far as can be ascertained now, most, if not all of the onions grown in New Mexico are produced according to the old way which, as already stated, consists in planting the seed out in the field and thinning the plants to the required distance in the row. As a rule better results can be had if the seed is planted in the fall, during September and the first of October. The seed-bed should be kept well irrigated during the winter.

#### Thinning in the Field

When the seed has been started in the fall, the thinning of the onions can be done during March or the first of April. Thinning should be done as early in the spring as possible. Thinning onions, when properly done, is a laborious and expensive operation,—more so than is generally considered by most of the onion growers. There are always a lot of vacant spots in the rows due usually to poor germination. This means that onions have to be transplanted in these vacant spots. It is slow work to thin out the small onions and leave

in place, at the proper distance in the row, the plants that are to remain without disturbing them. If the onions are quite thick and have come up in bunches, and if the soil is at all hard or sticky, the thinning is a still slower and more difficult process. If the workmen are not careful, they are liable to pull all of the onions and not leave the one in its proper place. If this is done, it is then necessary to trans-



Fig. 1—Onions Started in a Cold Frame Ready for Trans-Planting.

plant one of the onions where the bunch was, which practically amounts to the same thing as transplanting.

An idea may be had of what it costs to thin onions in the field, where irrigation is practiced, from the following results obtained at the Experiment Station on a small plat, in 1902. One-tenth of an acre plat,

which had been seeded to onions, was thinned out in the spring. The rows in this plat were 15 inches apart, while the onions were left every 4 inches in the row. The cost of thinning this plat was \$4.10. At this rate, the thinning of an acre would be \$41.00.

#### **"New Method"**

This consists in growing the onion seedlings in a cold frame or seed-bed, and then transplanting them to the field. This

plan, while not really new, is being advocated by many of the onion-growers as being better than the old way. The operation of transplanting onions is slow and is usually considered an expensive one. For this reason, the inexperienced onion-grower is liable to think it is too laborious and not a paying proposition; but, as a matter of fact, it is no more expensive than the thinning of onions in the field. The results of the experiments with onions at the Experiment Station show that it is cheaper to transplant than to thin a given area.

#### **Onion Seed**

Seed should be purchased from reliable firms, even though it may cost more, for it always pays to get good fresh seed. Cheap onion seed is liable to be poor and may mean mixed varieties, lack of uniformity in the crop, or the production of scullions. Farmers and gardeners frequently buy their seed in the small packets which are sold at the local stores. This is not a good practice, as such seed is liable to be quite old. Onion seed is slow to germinate and the little plants are delicate and slender-rooted at first. The fresher and more vigorous the seed, the better the germination and the stronger the plants. The germinative vitality of onion seed decreases quite rapidly with age. Our seed was secured from W. A. Burpee's of Philadelphia.

#### **Time to Sow Seed for Transplanting**

As already stated, in the Mesilla Valley the seed should be started in the fall, early enough for the onions to make a good root system before the cold season comes. In order to have the plants large enough to transplant out early in the spring, the seed should be sown in the open seed-bed some time in September or during the earlier part of October. If the seed is started in cold frames covered with glass, it can be sown later. Care must be taken to keep the seed-bed or cold frame well irrigated during the winter. A quarter of a pound of seed is usually enough to sow a seed bed six feet wide and from fifteen to twenty-four feet long, making ninety to one hundred and fourteen square feet. In case the size of the

seed-bed is changed, it should be made larger instead of smaller. The seed is usually planted in drills three to four inches apart. If the germination is good, the seedlings will be quite thick in the drill. At this rate, it will take from 3 to 4 and a half pounds of seed to the acre. This is about one and a half pounds less than when planted in the field.

#### **Preparation of Land for Transplanting**

In preparing land for transplanting onions, it should first be irrigated, then plowed, disced or harrowed, and smoothed.



**Figure 2 —Home-Made Marker for Marking Rows for Onions.**

After this, the rows should be laid off. This can be done by means of the home-made marker shown in Figure 2. It is a good idea not to prepare the land until the transplanting is to be done. If the land is prepared too long before the onions are set out, it will pack down and get hard and dry, and at the same time the weeds may make a considerable growth. If the land is moist and loose, the transplanting will be more easily and quickly done, as the dibber or garden trowel, which are good tools to use in this operation, make better holes for

the onions to be placed in. When the ground is too dry, as the dibber or garden trowel is taken out in making the hole, the dirt is likely to fall back in and fill the hole up. Such a soil condition tends to retard the work of transplanting.

### **Transplanting**

The onion is a crop which requires a cool season to develop most advantageously. From the results of the experiments at the Station, it has been found that better results are ob-



**Figure 3.—Transplanting Onions.**

tained when the transplanting is done early enough in the season, so that the plant will make most of its growth before the hot and dry months of June and July. The latter part of February or early part of March has been found to be a very good time for transplanting in the Mesilla Valley.

Many of the onion growers advise that the onions should be about the size of a lead pencil before they are transplanted. While this is a safe rule to follow, one should not be entirely bound by it. Frequently the onions are not quite that size by the time they should be set out. This means that the transplanting will have to be delayed or that the onions must be set out before they get to be the size of a lead pencil. It

seems to be a safer plan to transplant the onions at the proper season, though they be smaller than the size recommended, than to delay the transplanting until the onions grow larger. Many of the onions set out in the year 1903 at the Station were about half as large as a lead pencil, and some were even smaller. In 1904, all of the onions set out were about half the size that they should have been, according to the rule. Practically all grew and the results did not seem to be influenced by the size of the onion seedlings.

In transplanting a large number of onions, it is a good plan to do the work quickly; that is, to have enough help so that a large number of onions can be set out in a short time, in order that the first ones may not suffer before they are irrigated. It is also a good plan to have a boy drop the onion seedlings a little ahead of the men transplanting; in fact, better time can be made this way than when each man carries a bunch of onions and stops to pull one out every time before it is planted. If the boy works rapidly, he can drop enough for three transplanters. However, he must not drop too far ahead of the men, as the onions will wilt considerably before they are transplanted. About 5,000 is a good number for one man to transplant in a day.

#### **Distance to Transplant**

One of the principal things in view in raising onions is to produce a large yield; and in order to do this, all of the soil must be utilized to the best advantage. Most of the onion growers in the Rio Grande valley allow too much land to each onion. Ordinarily, the onions are planted about twelve inches in each direction and in this way the land is not made to produce all it can. The most common distance, where "hand culture" is practised, seems to be from twelve to fifteen inches between the rows and from four to four and a half inches in the row. Setting the onions out at these distances gives a larger number to the acre, varying from 100,000 to 120,000 onions or more. On the other hand, if "horse culture" is employed, the distance between the rows is usually in-

creased to at least thirty inches, thus reducing the number of onions to the acre.

#### **Cost of Transplanting**

Some idea may be had from the following as to the cost of transplanting onions. A one-tenth acre plat was transplanted with onions grown in a cold-frame in 1902. The rows were practically 335 feet long by 15 inches apart with the onions four inches in the row, making 1,005 onions to the row, or 10,050 to the plat. The cost of transplanting this plat of onions amounted to \$2.95. This included, besides the cost of transplanting, that of the first irrigation, bringing the onions from the seed-bed to the field, and dropping them ahead of the men transplanting, about the proper distance in the row. At this rate, it would cost \$29.50 to transplant an acre or 100,500 onions,—practically one-fourth cheaper than to thin the same area. In 1903, a one-fifth acre plat was transplanted on the 14th of March. The rows were 15 inches apart, and the onions four inches apart in the row. The cost of transplanting this plat was \$6.00. At this rate, the estimated cost per acre would come to \$30.00. In the spring of 1904, another one-fifth acre plat was transplanted, the onions being set out the same distance as in the previous years. It cost \$5.70 to transplant this plat. This would make one acre cost \$28.50. The average estimated cost per acre for the three years amounts to \$29.33.

#### **Irrigation**

Immediately after the onions are set out, they must be irrigated, and this should be followed with a second irrigation in about seven to eight days. Usually it takes about two irrigations to establish the little plants. The subsequent irrigations will vary more or less, depending on the soil and climatic conditions. Other things being favorable, the time between the irrigations to get good results, should be about every eight or twelve days. Since the onion is a surface feeder, it is very desirable that the upper portion of the soil be kept moist and cool. If possible, the plats should be ar-

ranged so that any excess of water may be drained off after each irrigation, especially on adobe soils. Care should also be taken not to allow the water to stand too long on the land. The soil must be kept uniformly moist throughout the growing period of the onion. If the soil becomes too dry, so that the plants stop growing and is then irrigated, the tendency is for many of the onions—especially if this occurs after the bulbs have made a considerable growth—to split into two or more parts. If this occurs, a part of the crop is liable to become unsalable.

#### **Irrigation with Muddy Water**

On July 30th, 1904, the onions were irrigated with very muddy ditch water. This water was so exceedingly thick with sediment that it was not safe to irrigate alfalfa, beans, tomatoes, and vines. The water, which had only been in the ditch about a week, was from the heavy rains which fell in what is known as the "Rio Puerco" region. The water that comes down this river is always very muddy, and usually considered not good to use, except on such plants as trees, corn and vegetables growing on ridges, such as chili.

At the time these onions were irrigated it was impossible to use pump water, and since the crop needed another irrigation before harvesting, the ditch water was used. Realizing the bad effects such muddy water generally has on many plants, before applying it, the writer inquired of the old time gardeners about the advisability of using such water on onions. The concensus of opinion doubted the advisability of using the water. A few of the gardeners believed the more developed bulbs would decay. In view of the lack of any definite information concerning this matter, it was thought this was a good opportunity to get some data on this subject. The onions were irrigated as heavily as at any other time during the season. After the water was dried up the sediment was so thick that all the bulbs were covered up with it. Two days after the irrigation, cloudy and rainy weather set in. For five days thereafter it rained enough to keep the sticky sed-



iment from drying up. At first, it looked as if the onions would rot; it was twelve days before the sediment dried up enough so that the ground could be worked. On August thirteenth, the onions were examined and it was found that they had not been injured by the muddy water.



Figure 4.—Using the "Planet Jr." Double Wheel-Hoe.

#### Number of Irrigations

In 1904, the one-fifth acre plat was irrigated twelve times. The first, second, and last irrigations were given with water from the ditch. All other irrigations were made with water from the Station pumping plant. The water from the ditch failed soon after March 21st, and the ditch remained dry until about the last of July.

The following are the dates of irrigation: March 12th, 21st, and 31st, April 16th, May 5th and 20th, June 5th and 22nd, July 7th, 15th, 22nd, and 30th.

**Cultivation**

As already stated, the onion delights in a loose, rich soil. In order to keep the soil loose, it must be kept stirred throughout the growing season. The cultivation of the onion is simple; it consists in keeping the soil loose and the weeds down. If possible, cultivate after every two irrigations. If "hand culture" is practised, the cultivation can be done with the "Planet Jr." double wheel hoe. This is the implement usually recommended for such work, and the one we have found to be the most helpful; it not only stirs up the soil and leaves it in good condition, but it also destroys all the weeds in the middles. Two or three hand weedings may be necessary during the earlier stages of growth. This operation consists mainly in taking out the weeds between the plants in the row. A narrow hoe, or Lang's Hand Weeder, are helpful tools.

The following table shows the dates of and the time required for each cultivation on the one-fifth acre plat during 1904:

|       |                    |                  |
|-------|--------------------|------------------|
| April | 20th, Cultivating, | 7 hours, 10 min. |
| "     | 22-23, Weeding     | 14 " 20 "        |
| May   | 9th, Cultivating,  | 4 " 55 "         |
| "     | 16-17, Weeding,    | 12 " 30 "        |
| "     | 25th, Cultivating, | 7 " 10 "         |
| June  | 11th, Cultivating, | 7 " 10 "         |
| "     | 13th, Weeding,     | 8 " 55 "         |
| "     | 20th, Weeding,     | 7 " 25 "         |
| "     | 29th, Cultivating, | 5 " 20 "         |

**Horse Culture**

It is believed by many of the gardeners of this section that it is more profitable to cultivate by horse than by hand. While it is true that work can be done more easily and perhaps more quickly by means of a horse, there are but half as many plants to the acre as would be planted when hand culture is practiced. The rows should be about thirty inches apart—wide enough for a horse to walk between the rows. On the other hand when the work is done by means of a

wheel-hoe, the rows are about fifteen inches apart, making twice as many rows to a given area, and, accordingly the yield would be greater. In using the horse cultivator, there are usually about six inches of space on each side of the row of onions that has to be cultivated by either the wheel-hoe or

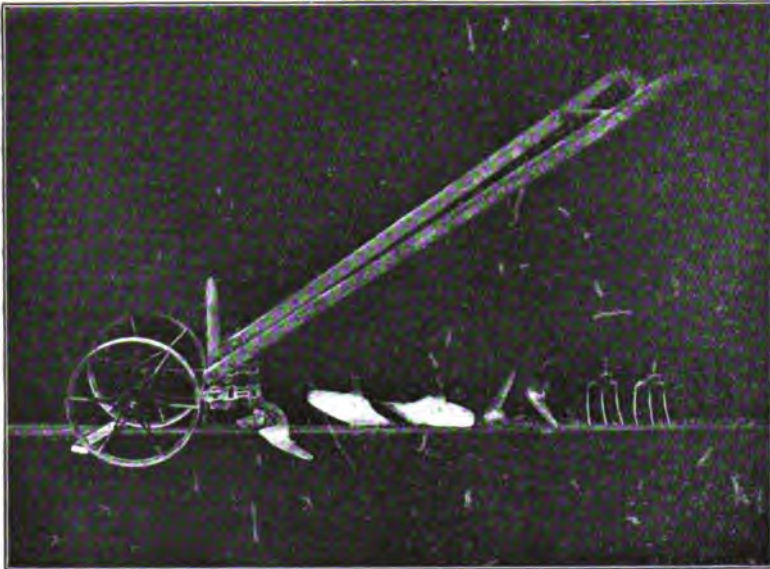


Figure 5.—"Planet Jr." Double Wheel-Hoe.

ordinary hand hoe. In the end much of the work done in fields where horse culture is practiced, is done by hand.

#### Harvesting

When the tops turn yellow and are beginning to die, the onions are ready to be harvested. This operation should not be delayed. Irrigation must stop when the ripening begins. Onions usually ripen unevenly, and some specimens will be green when most of the crop is ready to pull. It is not always a safe plan to wait until all of the tops are dried up; better pull the onions a few days too soon than a few days too

late. If they are left too long in the field after ripening, especially during wet weather, there is danger of some of them starting a new growth. A few days' delay after a new growth sets in may spoil a large part of the crop. The onions may be made to ripen more evenly if the tops be bent down at ripening time.

#### **Topping**

It is better not to remove the tops until after the onions have been pulled up and sunned for a day or so. The tops can be



**Figure 6.**—Onions Being Sunned in the Field Shortly After Topping Them cut off with an ordinary pair of pruning shears, and these we find to be preferable to a knife. About half an inch from the bulb is a good place to cut the tops off. It is better not to cut the tops any shorter than this.

#### **Storing**

If the onions are to be stored, after they are pulled, leave them out in the field a day or two. Care should be taken that

the sun does not burn them. Some of the white varieties, such as the Early White Queen and the White Pearl, &c., have thin skins and are easily burned by the sun. The onions should be perfectly dry before they go into the store room. Onions may appear to be perfectly dry and yet they will start to sprouting, causing quite a loss in some cases. It is not a good plan to let them stand in piles before they dry up, since they are liable to heat. The usual method of storing onions is to place them in crib-like shelves where they will have a free circulation of air. The layers may be from eight to twelve inches thick.

#### Yield.

Since the onion is a very expensive crop to grow, it is very important that as large a crop as possible be produced. The yield varies considerably, however. From three hundred to one thousand bushels per acre is the range in some of the onion-growing states, and a yield of from four to six hundred bushels is a good average crop. In New Mexico it is not yet definitely known what the average yield is per acre, although the yield at the Experiment Station in 1903 was very satisfactory. Two varieties, the Red Victoria and Prize Taker, grown on small plats, produced at the rate of 32,000 and 29,000 pounds of marketable onions per acre respectively. The onions were set out about the fifteenth of March. The land on which they grew received no special treatment whatever; the previous year the land was seeded to winter wheat and in the fall the stubble was plowed under and winter irrigated. In 1904 the yield was also very satisfactory. The land on which the crop grew this season was not as good for onions as that used the previous year. The Prize Taker produced at the rate of 25,680 pounds per acre, while the Gigantic Gibraltar, which was harvested August 27th, yielded at the rate of 31,250 pounds per acre. A one-twenty-fifth acre plat, which was fertilized with sodium nitrate, produced 1,618 pounds or at the rate of 40,450 pounds per acre.

In 1902 the yield was not satisfactory; the one-tenth acre on which the onions grew produced 1,185 pounds of market-

able onions, which is practically 12,000 pounds per acre. This is too low a yield and it might not pay to grow onions at this rate. The low yield secured in 1902 seems to have been largely due to the crop being set out so late in the season, and to the hard adobe soil in which the onions grew. The plats were transplanted the last of April. Another trouble that had something to do with the low yield of the crop was the splitting of a large part of the onions, which resulted

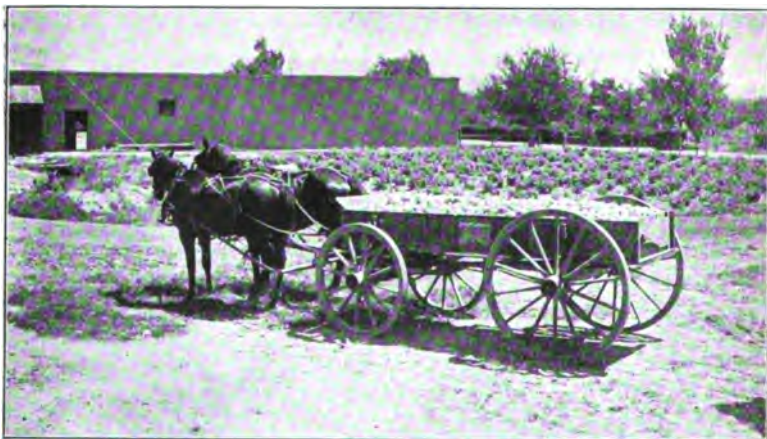


Fig 7. Load of 1,618 pounds of onions from the 1-25 acre plat, fertilized with sodium nitrate.

from the second growth setting in after the onions were ripening. This second growth seems to have been due to rainy weather.

#### Cost of Production

As has already been stated, onions are expensive to grow, and especially where fertilizers have to be used, but at the same time they are among the best paying crops. For the purpose of comparison, the cost of production in the East and South is given, as well as the cost at this Station. In "Onions for Profit," T. Greiner gives the following estimated cost of the crop per acre in the East:

|                                       |          |
|---------------------------------------|----------|
| Rent of land .....                    | \$ 6 00  |
| Manure, three car-loads, at \$16..... | 48 00    |
| Fertilizers .....                     | 25 00    |
| Hauling and applying manure.....      | 12 00    |
| Plowing and Harrowing.....            | 3 00     |
| Marking . .....                       | 1 00     |
| Raising 180,000 plants.....           | 30 00    |
| Seed .....                            | 7 00     |
| Transplanting.....                    | 45 00    |
| Cultivation and weeding.....          | 20 00    |
| Pulling crop.....                     | 3 00     |
| Gathering, hauling and packing .....  | 35 00    |
| <hr/>                                 |          |
| Total .....                           | \$235 00 |

Prof. P. H. Rolfs, in his book on "Vegetable Growing in the South," gives the cost of growing an acre of onions, not including crates, commission and freight, as follows:

|                                  |          |
|----------------------------------|----------|
| Raising plants .....             | \$ 30 00 |
| Rent of land .....               | 4 00     |
| Fertilizer and applying it ..... | 100 00   |
| Plowing and clearing .....       | 4 00     |
| Transplanting.....               | 40 00    |
| Seed .....                       | 5 00     |
| Cultivating.....                 | 20 00    |
| Harvesting.....                  | 45 00    |
| <hr/>                            |          |
| Total .....                      | \$248 00 |

The results at the Experiment Station show that the cost of production is less than the above figures represent. In the experiments at the Station, the rent of land and the cost of the fertilizers is not included. The following is the actual cost of growing one-tenth of an acre of onions at the Station in 1902:

|                                  |       |
|----------------------------------|-------|
| Plowing and leveling land .....  | \$ 30 |
| Marking and bordering land ..... | 20    |

|                                         |          |
|-----------------------------------------|----------|
| Transplanting .....                     | \$ 2 95  |
| Cultivating and irrigating .....        | 2 90     |
| Harvesting, topping and hauling .....   | 2 95     |
| Seed .....                              | 35       |
| Growing the plants, about .....         | 1 05     |
| <hr/>                                   |          |
| Total .....                             | \$ 10 70 |
| Estimated cost per acre, ten times .... | 107. 00  |

This amount does not include crates, commission, or freight.

The cost of production was slightly higher for 1903 than for the previous year. The following is the actual cost of one-fifth of an acre:

|                                       |         |
|---------------------------------------|---------|
| Plowing and leveling .....            | \$ 60   |
| Marking and bordering land .....      | 50      |
| Transplanting .....                   | 6 00    |
| Cultivating and irrigating .....      | 5 15    |
| Harvesting, topping and hauling ..... | 7 10    |
| Seed .....                            | 70      |
| Growing sets, about .....             | 2 00    |
| <hr/>                                 |         |
| Total .....                           | \$22 05 |

Estimated cost per acre will be five times this amount, or \$110.25.

In 1904 the cost of raising one-fifth acre plat of onions was as follows:

|                                       |         |
|---------------------------------------|---------|
| Plowing and leveling land .....       | \$ 70   |
| Marking and bordering .....           | 55      |
| Transplanting .....                   | 5 70    |
| *Cultivating and irrigating .....     | 6 15    |
| Harvesting, topping and hauling ..... | 6 50    |
| Seed .....                            | 75      |
| Raising sets .....                    | 2 00    |
| <hr/>                                 |         |
| Total .....                           | \$22 35 |

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\*The cost of pumping the well water is not included.



At this rate, the estimated cost per acre will come to five times \$22.85 or \$111.75.

Thus it is seen that, according to these estimates, it is possible to grow onions cheaper here than in some of the onion-growing sections in other states. Since the cost of production is less and the yield equal to if not greater than that of other states, it seems that onion raising could be made profitable in many parts of the Territory, provided the crop can be sold to advantage.

#### Varieties

With onions as with other plants, some varieties are better suited than others to different sections. Of the number tested at the Experiment Station, some have been found to do poorly, while others have given very satisfactory results.

The Early White Queen, Barletta, White Bermuda and the Extra Early White Pearl are quite satisfactory for early ripening. As a rule, they are not good keepers. The bulbs are medium in size, flat, and with a thin, glossy white skin; the tops are also small. They are very mild onions. The Early White Queen is perhaps the best all round table onion in the test. The Red Victoria has given the best yields of any of the varieties in unfertilized soils. It is a very large and somewhat globe-shaped onion, and a medium keeper. If a large, red and fair keeper but heavy yielding onion is desired, the Red Victoria would be recommended. The Prize Taker and Gigantic Gibraltar are both very good keepers and excellent yielders. These onions are yellow in color, globe-shaped, and very solid. They look very much alike in every respect. The Gigantic Gibraltar is preferable to the other two mentioned. The Australian Brown has given very satisfactory results as a late keeping variety. It is medium in size, brown, and very solid; ripens early and is a sure cropper. It will always make bulbs—whether conditions are favorable or not. It is not as heavy a yielder as the other onions mentioned.

## White Onions



Fig. 8.—1. White Victoria. 2. Extra White Pearl. 3. Large White Globe (True Southport Strain). 4. Giant White Italian Tripoli. 5. Philadelphia Silver Skin. 6. Early White Queen. 7. Neopolitan Maggajola. 8. New Mammoth Silver King.

## Red and Yellow Onions



Fig. 9.—9. Mammoth Pompell. 10. Extra Early Red. 11. Prize Taker. 12. Large Red Globe (True Southport Strain). 13. Red Victoria. 14. Round Yellow Danvers. 15. Australian Brown. 16. Large Red Wethersfield. 17. Mammoth Red Tripoli. 18. New Giant Red Rocca.

### **Insects and Diseases**

As yet no diseases of any kind and no serious insect pests have been observed at the Station, and none have been reported from other sections of the Territory. The Thrips, which is often seriously injurious to onions in other states, was observed in a very limited number last season.

### **Markets**

This subject has received little attention here. We frequently hear that there is no market for this, as well as other crops. As already stated, there are not enough onions grown to even supply the home market throughout the year. There is no doubt that the local merchants would buy more of the product if they were sure of being supplied right along. As long as the production is so small, it need not be expected that markets can be secured. If large quantities of onions were produced, so that shipments could be made on a larger scale, there is no doubt but that better and more permanent markets could be secured within as well as outside the Territory.

### **Fertilizers\***

In the onion-growing states, the practice of applying fertilizers to the land, either in the form of barn-yard manure or as commercial fertilizers, is very necessary in order to increase the yield. While the application of fertilizers would, no doubt, increase the yield per acre of onions in the Mesilla Valley, this practice is not followed here. Good soils will produce heavy yields without any fertilizers. The yield produced during the past two seasons on land without any fertilizer was as large as the average yield reported from other states. However, a beginning has been made to test the fertilizers. In 1904, one twenty-fifth of an acre plat of the Gigantic Gibraltar onion was fertilized with sodium nitrate, obtained from the "Nitrate of Soda Propoganda," of New York. The ground was more or less adobe and tends to pack

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\*This part of the work was done in co-operation with Professor R. F. Hare, Station Chemist.

after an irrigation. The soil in this plat seems to be below the average for onions.

The onions were transplanted on March 12, 1904, in rows 15 inches apart and four inches in the row. The sodium nitrate was used at the rate of 600 pounds per acre, or 24 pounds per plat, and it was applied at four different times during the season. The following shows the amounts applied and dates of application: May 9th, 4 pounds; May 28th, 6 2-3 pounds; June 11th, 6 2-3 pounds; and June 30th, 6 2-3 pounds. In each case the nitrate was broad cast and then raked in. On May 28th it was observed that the nitrate was already acting on the growth; at this date, the tops of the onions were larger than on onions not fertilized. On June 14th, the rank and vigorous growth was very noticeable. The onions were harvested August 25th and 27th.

The following figures will show in detail the yield from the fertilized and unfertilized plats:

|                               | Fertilized | Unfertilized | Difference |
|-------------------------------|------------|--------------|------------|
| Area .....                    | 1-25 acre  | 1-25 acre    |            |
| Fertilizer applied .....      | 24lbs      | .....        |            |
| Actual yield .....            | 1,618lbs   | 1,250lbs     |            |
| Actual difference .....       | .....      | .....        | 368lbs     |
| Estimated yield per acre..... | 40,450lbs  | 31,250lbs    |            |
| Estimated difference .....    | .....      | .....        | 9,200lbs   |
| At 2c per pound .....         | \$809 00   | \$625 00     |            |
| Estimated difference .....    | .....      | .....        | \$184 00   |

As may be seen from the table, the unfertilized plat, which was given the same treatment, except the application of sodium nitrate, yielded at the rate of 31,250 pounds of onions per acre; while the fertilized plat yielded at the rate of 40,450 pounds per acre, the increase in yield being 9,200 pounds per acre, or 29.6 per cent. If the onions could be marketed at the rate of two cents per pound, this would give an increased value of \$184.00 to the acre. Since 600 pounds of nitrate of soda costs \$32.40,\* and its cost of application to the

\*The Texas Seed and Floral Co., of Dallas, Texas, quotes nitrate of soda at \$4.00 per 100 pounds f. o. b. Dallas

The freight rate from Dallas to Mesilla Park, N M., which has been kindly furnished by the local agent of the A. T. & S. F. R. R., is \$1.40 per 100 pounds.

soil would be about \$2.00, there would be a net increase in the profits of \$149.60.

Less than 600 pounds may prove to be just as beneficial, and possibly fewer applications. These are points yet to be determined. From the first year's experiments, it would certainly seem to indicate that the application of nitrate of soda increases materially the yield of onions. Further work will be done along this line.

### Second Growth

It has been observed during the onion test that, if the growth of the onion is partially or wholly checked while the bulb is developing, there is a tendency—especially among some varieties—to produce an entirely new



Fig. 10. 1. Bulbs splitting due to second growth.  
2. Sound bulbs.

growth, if the onion starts to growing again. This second growth seems to be the result of an irrigation given after the onions have been allowed to suffer from lack of water. When this second growth occurs, the plant usually divides or splits into two or more parts (Figure 10-1). This dividing of the onion may be of such extent that frequently the bulb is ruined for commercial or keeping purposes. If the onions should stop growing shortly before ripening, it is not considered advisable, judging from the results at the Station, to irrigate them after that. It seems better to harvest the bulbs, though they may be somewhat immature.

### Keeping Test

In the comparative keeping test of the varieties grown, the onions placed on the shelves each year were kept under the same conditions. These tests were carried on for two years, 1902 and 1903. Practically the same varieties were used each year, except that in 1903 the number of varieties was smaller and the onions were placed on the shelves a few days earlier than in the previous year. The shelves were made in sections, one on top of the other on a movable frame, in such a way that the onions when placed in them had a free circulation of air both above and below, as well as from the sides. Where a large number of onions were used, they were two or three deep; otherwise they were only one deep. The frame was placed in one corner of a large adobe room. No fire was kept in it during the winter and most of the time the doors were open in the daytime. The onions were not placed in the shelves until they had dried thoroughly. In 1902, they were placed in the shelves on September 15th, while in 1903 the test started on the 25th of August, thus making the latter lot twenty days longer in the shelves. No rule was adopted as regards the number of specimens of each variety placed in the test. In every case, the most convenient number was taken, as there were only a few bulbs of some of the varieties. The number and weight of each variety were taken at the time the onions were placed in the test. On January 22nd in each year, the onions were sorted, counted, and weighed. In 1902, the specimens were in the test 127 days, while in 1903 they remained 147 days. At the time the observations were taken, three divisions were made of each variety; sound, those that were sound but were just beginning to sprout, and those that had sprouted. Those that were just sprouting, and which were counted in as marketable, were quite solid and by simply cutting off the small sprout they could be utilized at that time. Of course, such onions would become worthless in a short period if no use were made of them immediately.

1903-1904

Observed January 22, 1904

|   | Just<br>routing.<br>market-<br>able. | Sprouted<br>badly.<br>Not<br>marketable |       | Total<br>weight |     | Loss in weight<br>during test |     |       |
|---|--------------------------------------|-----------------------------------------|-------|-----------------|-----|-------------------------------|-----|-------|
|   | %                                    | No.                                     | %     | lbs.            | oz. | lbs.                          | oz. | %     |
| A | 0                                    | 0                                       | 0     | 19              | 0   | 2                             | 0   | 9.52  |
| A | 5                                    | 0                                       | 0     | 4               | 11  | 0                             | 5   | 6.25  |
| E | 60                                   | 8                                       | 32    | 7               | 3   | 1                             | 5   | 15.44 |
| E | 46                                   | 21                                      | 42    | 6               | 8   | 2                             | 0   | 23.52 |
| G | 33.33                                | 6                                       | 40    | 4               | 14  | 1                             | 2   | 18.75 |
| G | 46.66                                | 6                                       | 40    | 6               | 8   | 2                             | 11  | 32.62 |
| L | 30                                   | 1                                       | 10    | 2               | 0   | 0                             | 5   | 13.51 |
| L | 21.42                                | 0                                       | 0     | 3               | 8   | 0                             | 8   | 12.50 |
| L | 0                                    | 0                                       | 0     | 6               | 15  | 0                             | 13  | 10.48 |
| M | 20                                   | 9                                       | 60    | 7               | 5   | 3                             | 3   | 30.35 |
| M | 60                                   | 3                                       | 30    | 4               | 1   | 1                             | 7   | 26.13 |
| M | 30                                   | 1                                       | 5     | 4               | 6   | 0                             | 8   | 10.00 |
| N | 26.66                                | 3                                       | 20    | 5               | 4   | 0                             | 12  | 12.50 |
| N | 33.33                                | 9                                       | 60    | 4               | 3   | 2                             | 1   | 33.33 |
| P | 10                                   | 0                                       | 0     | 4               | 6   | 0                             | 8   | 10.25 |
| P | 10                                   | 0                                       | 0     | 15              | 0   | 0                             | 12  | 4.76  |
| R | 14.47                                | 7                                       | 9.21  | 33              | 15  | 4                             | 1   | 10.69 |
| R | 0                                    | 0                                       | 0     | 2               | 0   | 0                             | 2   | 5.88  |
| S | 25                                   | 0                                       | 0     | 6               | 11  | 0                             | 8   | 6.95  |
| W | 4                                    | 0                                       | 0     | 7               | 0   | 0                             | 12  | 9.67  |
| W | 40                                   | 14                                      | 56    | 5               | 14  | 2                             | 2   | 26.56 |
| Y | 6.66                                 | 1                                       | 6.66  | 4               | 3   | 0                             | 4   | 5.63  |
| Y | 14.28                                | 3                                       | 21.42 | 2               | 4   | 0                             | 10  | 21.73 |





A careful study of the table will show the relative percentages of marketable and unmarketable, etc., of the different varieties. It will also be seen that the best keepers lose less in weight than the poor-keeping kinds. There was practically no loss in weight in these tests from decay; the loss in weight comes from evaporation, scaling off, and sprouting. Small specimens tend to keep longer than larger ones of the same variety. From the data in the above table, the following list of onions have been taken, showing the best and poorest keeping varieties in the test:

List of varieties which average, for the two years, not less than ninety per cent. of sound onions at the end of the test: Australian Brown, American Prize Taker, Australian Yellow Globe, Extra Early Red, Gigantic Gibraltar, Large White Globe (True South Port Strain), Philadelphia Silver Skin, and Round Yellow Danvers.

List of onions, averaging for the two years, not less than eighty per cent. of sound bulbs at the end of the test: Those enumerated in the above, and the Large Red Wethersfield, Prize Taker, Yellow Dutch Strassbury, and White Silver Skin or White Portugal.

Onions averaging for the two years, not less than eighty per cent. of marketable bulbs (sound and those just sprouting): Those already mentioned, and the Large Red Globe (True South Port Strain), Michigan or Ohio Globe, and South Port Large Yellow Globe.

List of onions averaging not over 40 per cent. for the two years, of sound bulbs: Early White Queen, Extra Early White Pearl, Giant Rocca, Giant White Italian Tripoli, Giant Yellow Rocca, Mammoth Red Tripoli, Neapolitan Maggiojola, Red Bermuda, and White Victoria.

The Australian Brown, Gigantic Gibraltar, Prize Taker, and Red Victoria have been grown on a large scale and they have given good results. The rest of the varieties in the first three lists have only been grown in small rows, but the America Prize Taker, Extra Early Red, Large White Globe (True South Port Strain), Philadelphia Silver Skin, White

Silver Skin or White Portugal, and Australian Yellow Globe, are among the most promising kinds. The other varieties grown in rows have given poor results, except for being good keepers.

#### Descriptions

**American Pink Prize Taker**—Size medium to large, roundish to globe-shaped, solid, good keeper; color pink.

**Australian Brown**—Size small to medium, roundish to globe-shaped, very solid, excellent keeper, attractive, ripens early, does not tend to divide; color brown; fair yielder.

**Australian Yellow Globe**—It looks very much like the Australian Brown, except in color, which is lighter.

**Barletta**—Size small, flat, poor keeper, early; color white. It is believed to be identical with the Early White Queen.

**Extra Early Red**—Size small, roundish flat, solid, good keeper, tends to split; color red to purple.

**Extra Early White Pearl**—Size small to medium, flat, poor keeper, mild, early, no tendency to divide; color white, thin skin.

**Early White Queen**—Size small to medium, flat, very mild, poor keeper, very early, does not divide; color white, thin skin; fine table variety.

**Gigantic Gibraltar**—Size large to very large, roundish to globe-shaped, very attractive, good keeper, good yielder and produces a very uniform crop of solid bulbs; color yellow; it is similar to the Prize Taker, except it is lighter in color and the tops, which are large, are not glaucous; it is very promising.

**Giant Rocca**—Size medium, roundish to globe-shaped, attractive, poor keeper, divides badly; color pink.

**Giant White Italian Tripoli**—Size large, roundish flat, fair keeper, tends to divide; color white, moderately thin skin, attractive.

**Large Red Globe (True South Port Strain)**—Size small, globe-shaped, fair keeper, there is a slight tendency to divide; color red.

**Large Red Wethersfield**—Size very small, roundish flat,

solid, fair to good keeper, not attractive, poor yielder, tends to divide; color red.

**Large White Globe (True South Port Strain)**—Size medium to large, globe-shaped, very solid, good keeper, tends to divide; color white; promising.

**Mammoth Pompeii**—Size very large, flat, poor keeper; there is a slight tendency to divide, medium-sized tops; color red to purple.

**Mammoth Red Tripoli**—Size large, flat, poor keeper, tends to divide; color red to purple. It resembles the Pompeii.

**Michigan or Ohio Yellow Globe**—Size small, globe-shaped, fair keeper, tends to divide; color yellow.

**New Giant Red Rocca**—Size medium, roundish to globe-shaped, very solid, poor keeper, tends to divide; color pink to red.

**Neopolitan Magglojola**—Size large, flat, medium-sized tops, poor keeper, tends to divide; color white, thin skin.

**Philadelphia Silver Skin**—Size small, roundish to globe-shaped, solid, good keeper, divides badly; color white.

**Prize Taker**—Size large, roundish to globular, solid, attractive, good keeper, and good yielder; a few tend to split; color yellow.

**Red Bermuda**—Size medium to large, flat, fairly solid, poor to fair keeper; color dark red.

**Red Victoria**—Size very large, globe-shaped, solid, fair keeper, large tops, there is a slight tendency to split; color dark pink.

**Round Yellow Danvers**—Size small, roundish to flat to angular, good keeper, divides badly; color yellow; undesirable mostly on account of size.

**South Port Large Yellow Globe**—Size medium to large, roundish globe, very solid, attractive, fair keeper, there is a slight tendency to divide; color yellow.

**White Bermuda**—Size small to medium, flat, poor keeper, early, mild, bulbs burn easily by the sun if they are allowed to remain too long out after they have been pulled up; color glossy white; skin thin, small tops.

**White Silver Skin or White Portugal**—Size medium, roundish to globular, solid, divides slightly, good keeper, promising; color silver white, thin but tough skin, attractive.

**White Victoria**—Size medium, roundish with a slight tendency to flattening on top, moderately solid, poor keeper, divides badly; color white.

**Yellow Dutch or Strassbury** — Size small to medium, roundish, semi-globe to angular, very solid, fair to good keeper, there is a slight tendency to divide; medium-sized tops; color yellow.

**Yellow Globe Danvers**—Size small, globe-shaped, solid, small tops; color yellow; fair keeper, tends to divide.

#### Summary

1. Onions can be successfully grown in New Mexico.
2. The "New Method" has been more satisfactory at the Station than the old.
3. Onions for transplanting should be started in the early fall, and the seed bed should be kept well irrigated during the winter.
4. Other things being equal, the earlier the transplanting in the spring, the better the results.
5. Very small onions, half as large as a lead pencil, can be transplanted with equally as good results as when they are larger.
6. On rich, loamy soils, very heavy yields can be produced from some of the larger varieties, under ordinary treatment.
7. In stored onions, there is little or no decay; practically the whole loss comes from sprouting.
8. Transplanting is no more expensive than thinning out in the field.
9. The estimated cost of production is less than the cost reported from many other onion-growing states.
10. Under ordinary treatment, the cost need not exceed \$125.00 per acre.
11. In order to get a better market and more steady

prices, onions should be grown on a larger scale. As long as the supply is so exceedingly limited, the market is not likely to be bettered.

12. Light and frequent irrigations should be practiced, instead of heavy ones at long intervals.

13. The checking of growth, especially when the bulbs are forming, and then irrigating afterwards, tends to produce a new growth in certain varieties, which, as a rule, is a detriment to the crop.

14. Water should not be allowed to stand too long in the low places. If possible, the plats should be so arranged that all of the extra water due to excessive irrigation can be drained off.

15. The very muddy water, which comes from the "Rio Puerco," does not seem to be injurious to the bulbs.

16. Frequent cultivation is very necessary.

17. The "Planet Jr.," double wheel hoe, does very satisfactory work and is a good labor-saving machine.

18. By bending over the tops at ripening time, the onions seem to mature very evenly.

19. Onions are at present free from any fungous diseases or any insect pests, at the Station.

20. Fertilizers, especially on poor soils, may increase the yield materially.

21. "Hand Culture" is preferable to "horse culture."

22. Onions are not as perishable as many other crops. Many varieties can be kept until late in the season, and thus a better price secured for them.

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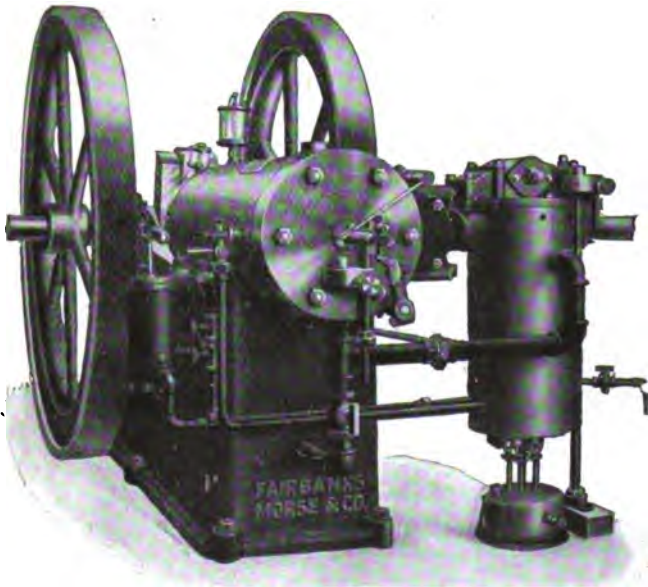
# **BULLETIN NO. 53**

OCTOBER 1904

**New Mexico College of Agriculture and Mechanic Arts**

**AGRICULTURAL EXPERIMENT STATION**

**MESILLA PARK, N. M.**



## **PUMPING FOR IRRIGATION**

**A Fuel Test of Crude Oil, Kerosene and Gasoline**

BY

**JOHN J. VERNON, FRANCIS E. LESTER and HENRY C. McLALLEN**

SANTA FE, N. M.:  
NEW MEXICAN PRINTING COMPANY,  
1904.

# NEW MEXICO AGRICULTURAL EXPERIMENT STATION

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on application to the Director



## SUMMARY AND CONCLUSIONS

1. The equipment used in these tests consisted of a 22 H. P. Fairbanks, Morse & Co's. gasoline engine with a crude oil attachment, and a six-inch centrifugal pump made by the same firm, which was placed upon the six-inch well described in Bulletin No. 45 of this Station.

2. Crude oil from Beaumont, Texas, was successfully used in the above named engine during the short series of tests made on the Station farm.

3. The operation of the engine on crude oil, after its mechanism was understood, was not difficult.

4. Crude oil was proven to be the cheapest fuel yet tested at this Station; that is, cheaper than wood, coal, kerosene, or gasoline. The cost of a ten hour run with the above named engine on each kind of oil was as follows: Crude oil, \$3.05, kerosene \$6.57, and gasoline \$6.65. Therefore, for a ten hour run, crude oil cost  $53\frac{1}{2}$  per cent less than kerosene and 54 per cent less than gasoline, all being used in the same engine under practically identical conditions.

5. The residue from the crude oil was used as a lubricant on ordinary bearings with good effect. The residue also gave good results when used on the streets for laying the dust.

6. Rope belting was not satisfactory in these tests.

7. Large engines when used for pumping purposes should always be provided with friction-clutch pulleys so that they may be started without load.

8. The tests should be continued in order to determine if difficulties will develop with extended use. Arrangements have recently been made to this end.

## INTRODUCTION

In a country in which fuel, such as wood and coal, is scarce or high in price, it often becomes necessary to use internal combustion engines for the production of power; that is, engines in which gasoline, naphtha, crude oils, etc. are used for fuel.

Some parts of New Mexico are abundantly supplied with wood or coal. In parts not so favored by nature in this respect, these fuels are invariably high in price, a condition which is due in a great measure to the high transportation charges which seem to be unavoidable in a mountainous country. Since New Mexico is a mountainous region, it would seem expedient to use forms of fuel other than wood or coal; those which are not so bulky, and which, therefore, can be more cheaply transported.

Agricultural crops in New Mexico are almost wholly grown by the aid of irrigation and since large areas, which for various reasons cannot be supplied with water by gravity systems, must depend for their development upon irrigation by pumping, cheap fuel is essential. This leads to an inquiry as to which is the cheapest fuel available. It is believed that information regarding the relative value of the different kinds of fuel for the production of power is of the utmost importance. The Agricultural Experiment Station at Mesilla Park has taken up the investigation of the subject as applied, in particular, to pumping water for irrigation from the underflow.

The results of the experiments on this subject so far published are to be found in Bulletin No. 45 of this Station. The tests referred to were made with what later proved to be a poor pump. Nevertheless, the relative fuel values given are probably correct, although the returns for the fuel no doubt ran low; that is, the quantity of water pumped with the consumption of a given amount of fuel was less in this case

than it would have been if one of the best pumps had been used. A repetition of the test, using one of the best pumps, will be necessary to determine the maximum return for fuel consumed.

The present bulletin deals with tests of (Beaumont, Texas) crude oil, kerosene, and gasoline when used in a gasoline engine supplied with an attachment for utilizing crude oil and kerosene.

### **PURPOSES OF THE EXPERIMENT**

1. To determine whether (Beaumont, Texas) crude oil can be used successfully as a fuel in an internal combustion engine.
2. To determine the relative value of crude oil, kerosene, and gasoline as fuels for use in an internal combustion engine.

### **EQUIPMENT**

The equipment consisted of a 22 H. P. Fairbanks, Morse & Co's. gasoline engine with a crude oil attachment, and a six-inch centrifugal pump made by the same firm, connected with the engine by an endless rope belt provided with an automatic tightener. This outfit complete was loaned to the Experiment Station by Fairbanks, Morse & Co., Denver, Colorado, for the purpose of making the test.

The pump was placed upon the six-inch Station well which is described in Bulletin No. 45. The engine was placed upon a solid concrete foundation and properly housed.

### **The Crude Oil Attachment**

The crude oil attachment consists of a carburetor made in the form of a small upright boiler set upon legs and connected with the intake and exhaust of the gasoline engine, (see Plate 1). The exhaust from the engine is made to heat the carburetor to the desired temperature, a condition which results in the formation of a gas from the volatile portions of the crude oil. The gas, being lighter than the air, rises to the top of the carburetor from whence it is drawn into the

engine. The gas is mixed with more air as it passes the air valve. The residue from the crude oil drops to the bottom of the carburetor and is drawn off. The carburetor is heated either

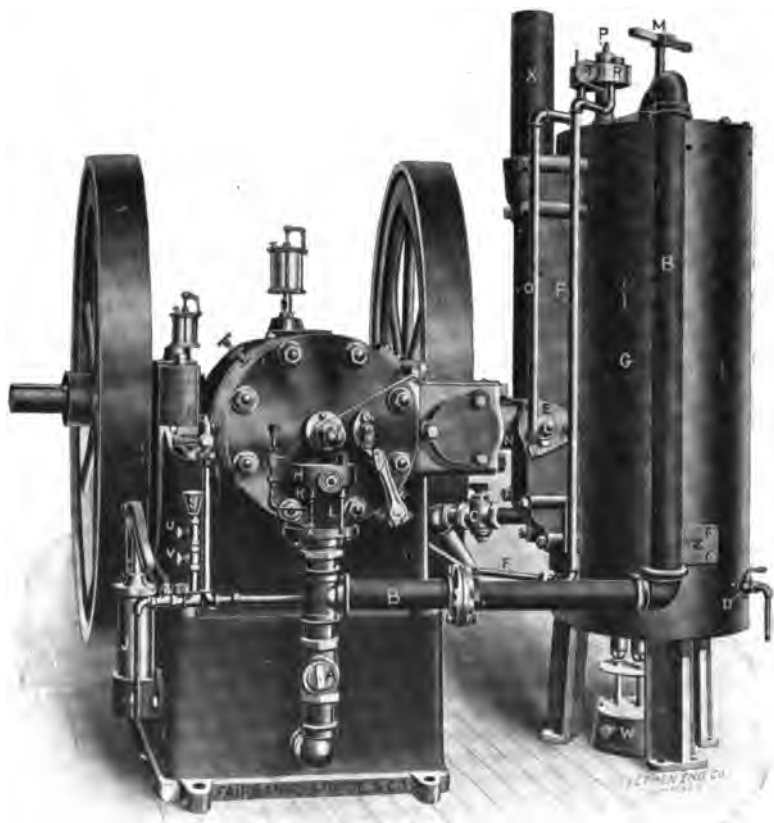


Plate I.—Showing the Crude Oil Attachment.

by placing a burner underneath it or by running the engine on gasoline long enough for it to become heated by the exhaust. The temperature of the carburetor, the supply of the crude oil to the carburetor, the supply of the gas from the carburetor to the engine, the amount of air to be mixed

with the gas, and the quantity of water to be thrown into the gas chamber with the mixture of gas and air, are all regulated by valves. At first, the manipulation of the many valves seemed complicated and difficult, but upon a careful study of the instructions and after repeated trials the adjustment of the valves became simple. After the best position for each valve had been determined and marked, it became an easy matter to make the necessary readjustments in order to conform to the variations of the atmosphere and thus to obtain the greatest amount of power from the oil consumed.

#### MIXING WATER WITH THE GAS

When running on gasoline the engine did not pound, but when crude oil was used the pounding was marked. However, the makers have provided a way for correcting this difficulty. A small jet of water is thrown into the gas chamber with the gas. This water is drawn from the cooling chamber and requires no extra attachments other than one to connect the water chamber with the gasoline feed. The gasoline feed is not in use when the engine is being run on crude oil, and, therefore, it is free to be used for the purpose named. Practically all of the pounding disappeared with the introduction of the water into the gas chamber. The makers assert that there is no loss of power by this method of preventing the pounding, and the results obtained seemed to indicate that this is true, since the speed of the engine did not noticeably decrease when the water was introduced.

#### CLOGGING AND GUMMING

So far as could be determined with the length of the test given, there was no clogging or gumming. After running the tests the engine head was removed and the valves and valve seats were carefully examined. There could be found no indications of a deposit of any kind upon the valve seats. It has been suggested that this clean condition may have been due to the fact that the engine each day was run on gasoline long enough to heat the carburetor and this gasoline, which passes

the valve in the form of a spray, may have dissolved the deposit, if any was formed, thus keeping the valves clean. If it is proven that the valve seats can be kept clean by the use of gasoline in starting, possible objections on account of clogging in these parts can have very little weight.

#### COST OF FUEL

The crude oil used in the test was purchased in El Paso, Texas, and shipped by local freight to Mesilla Park. It cost \$2.82 per barrel of 50 1-2 gallons, or about 5 3-5 cents per gallon delivered at the Station farm. The kerosene oil was purchased at Las Cruces from the Continental Oil Co., and cost 19 1-5 cents per gallon by the barrel delivered. The gasoline was purchased from the same firm as the kerosene and cost 20 1-5\* cents per gallon by the barrel delivered.

#### WEIGHT OF THE OIL

A given quantity of each kind of oil was carefully measured in a graduate and weighed. The following table shows the weight of one gallon of each kind of oil tested:

| Kind of oil    | Pounds | Ounces            |
|----------------|--------|-------------------|
| Crude oil..... | 7      | 9                 |
| Kerosene.....  | 6      | 11- $\frac{1}{2}$ |
| Gasoline.....  | 5      | 15                |

The quantity of oil consumed by the engine was determined as follows: the tank of oil was weighed before and after each run, and from the difference in the weights and the data given in the above table the quantity of oil used was computed.

In making the tests with crude oil and kerosene, the engine was run on gasoline until the carburetor was heated to the proper temperature, when the engine was transferred to crude oil or kerosene. The amount of gasoline consumed in heating the carburetor and the length of time the engine ran on gasoline were recorded. The cost of the gasoline used in starting each day was included with the cost of running on each kind of oil.

\*Since the tests were made the price of gasoline has dropped to 17 1-5 cents per gallon by the barrel delivered.

### ROPE BELTS

During the experiments on the Station farm, a rope belt was used and it gave considerable trouble, resulting in repeated delays in the work. This was no doubt due to the method in which it was used. The rope passed from the engine pulley to a sheaf (grooved pulley for rope belt) at the surface of the ground, from this sheaf around the tightener pulley and back to the same sheaf, down to the pulley on the pump, back to a second sheaf at the surface of the ground, thence back to the engine (see Plate II). Probably no trouble would have been experienced if a counter-shaft had been used and the belt run in two sections, one from the engine to the counter-shaft, and the other from the counter-shaft to the pump.

### FRICTION-CLUTCH PULLEY

Whenever a large gasoline engine is used, a friction-clutch pulley should invariably be provided. This permits of starting the engine without load. The load may then be thrown on after the engine is up to speed. The friction-clutch pulley may be placed on the engine shaft, if direct connection is made between the engine and pump; or it may be put on the counter-shaft, if that method of connection is used.

In the experiments made with the 22 H. P. gasoline engine no friction-clutch pulley was provided. The extra load, which consisted of the empty pump, two heavy idler sheaves, and the automatic tightener pulley, had to be handled in starting the engine. It required two men to start the engine with this extra load on, while without this extra load it was found that one man could start it without difficulty.

### RESIDUE

The residue that remains after the crude oil is run through the carburetor consists of a thick black oil. This residue was used for some time as a lubricant upon ordinary bearings, such as those on the counter-shaft, with apparently no bad effects. It is quite probable that the residue may be of



Plate II.—Showing Rope Belt.



considerable value as a lubricant in which case the cost of pumping with crude oil will be materially reduced.

The residue has been shown to be a good dust layer. Two barrels were spread upon a portion of Main Street in Las Cruces, N. M. The one application laid the dust satisfactorily for three or four months.

Probably other uses for the residue may be discovered.

Tables I, II and III show in detail the results of the tests made on crude oil, kerosene and gasoline.

By a comparison of these tables it will be seen that the average lift and the quantity of the water discharged were slightly less, and that there was greater fluctuation in the readings, when crude oil was used than when either kerosene or gasoline was used. This is probably due to the fact that when running on crude oil a readjustment of the air valve must be made at intervals of two or three hours so as to maintain the proper mixture of gas and air. The air is lighter at mid-day than either in the morning or evening, and so the air valve must be opened as the noon hour approaches and then closed somewhat as evening comes on. When running on kerosene or gasoline a change in the position of the air valve was found unnecessary. The foregoing facts, the writers believe, account in part at least, for the slight variation in the readings when running on crude oil.

Table 1—Test on Crude Oil

Showing the results secured in seven runs, using crude-oil as fuel.

| No.      | Length of run<br>hrs. min. | Gallons Crude<br>Oil Consumed | Gallons Crude<br>Oil Consumed<br>per hour | Percent Crude<br>Oil Consumed | Speed<br>Revolutions per<br>minute<br>Engine Pump | Suction<br>Ft. In. | Discharge<br>Ft. In. | Total Lift<br>Ft. In. | Gallons per<br>minute<br>pumped<br>water | Time<br>reading<br>taken |
|----------|----------------------------|-------------------------------|-------------------------------------------|-------------------------------|---------------------------------------------------|--------------------|----------------------|-----------------------|------------------------------------------|--------------------------|
| 1        | 3—57                       | 18.44                         | 4.66                                      | 54                            | 202<br>199                                        | 23—10<br>23—1½     | 15—3<br>15—3         | 39—1<br>37—4½         | 1083<br>1083                             | 3:45 p. m.<br>6:50 p. m. |
| 2        | 8—30                       | 37.75                         | 4.44                                      | 56                            | 203                                               | 23—10              | 15—3                 | 39—1                  | 1140                                     | 9:50 a. m.               |
| 3        | 3—43                       | 18.77                         | 5.06                                      | 50                            | 203                                               | 24—5               | 15—3                 | 39—8                  | 1126                                     | 5:30 p. m.               |
| 4        | 7—57                       | 44.82                         | 5.64                                      | 43                            | 200<br>197                                        | 23—3¼<br>23—8      | 15—3<br>15—3         | 38—6¼<br>37—11        | 1066<br>1046                             | 1:30 p. m.<br>6:25 p. m. |
| 5        | 5—08                       | 23.40                         | 4.56                                      | 55                            | 207<br>201                                        | 25—3<br>23—3¼      | 15—3<br>15—3         | 40—6<br>38—6¼         | 1161<br>1100                             | 2:10 p. m.<br>5:10 p. m. |
| 6        | 7—53                       | 43.57                         | 5.53                                      | 46                            | 207<br>198                                        | 25—6<br>23—3¼      | 15—3<br>15—3         | 40—9<br>38—6¼         | 1147<br>1083                             | 2:35 p. m.<br>5:00 p. m. |
| 7        | 3—12                       | 19.17                         | 5.99                                      | 52                            | 202<br>194                                        | 23—3¼<br>21—0      | 15—3<br>15—3         | 38—6¼<br>36—3         | 1063<br>1026                             | 3:45 p. m.<br>5:10 p. m. |
| Average, |                            | 5.12                          |                                           | 51                            | 201                                               | 23—1               | 15—3                 | 38—8                  | 1089                                     |                          |

NOTE—The test was made with the pumping plant described on page five.

NOTE—In all of the tests the quantity of water pumped was determined by measurement with a Cippolletti weir and a hook gauge.

Table II—Test on Kerosene

Showing the results secured in two runs, using kerosene as fuel.

| No. | Length of run<br>hrs. min. | Gallons kerosene consumed |                            | Per cent kerosene consumed | Speed<br>Revolutions per<br>minute<br>Engine Pump | Suction |                | Discharge |     | Total Lift |                 | Gallons water pumped per minute | Time reading taken |
|-----|----------------------------|---------------------------|----------------------------|----------------------------|---------------------------------------------------|---------|----------------|-----------|-----|------------|-----------------|---------------------------------|--------------------|
|     |                            | Gallons kerosene consumed | kerosene consumed per hour |                            |                                                   | Ft.     | In.            | Ft.       | In. | Ft.        | In.             |                                 |                    |
| 1   | 7-31                       |                           |                            |                            | 204                                               | 24      | 5              | 15        | 3   | 39         | 8               | 1119                            | 10:30 a. m.        |
|     |                            |                           |                            |                            | 204                                               | 24      | 5              | 15        | 3   | 39         | 8               | 1113                            | 11:30 a. m.        |
|     |                            |                           |                            |                            | 204                                               | 24      | 5              | 15        | 3   | 39         | 8               | 1106                            | 12:30 p. m.        |
|     |                            |                           |                            |                            | 204                                               | 25      | $\frac{1}{2}$  | 15        | 3   | 40         | $3\frac{1}{2}$  | 1026                            | 1:30 p. m.         |
|     |                            |                           |                            |                            | 204                                               | 25      | $\frac{1}{2}$  | 15        | 3   | 40         | $3\frac{1}{2}$  | 1079                            | 2:30 p. m.         |
| 2   | 4-6                        |                           |                            |                            | 203                                               | 24      | 5              | 15        | 3   | 39         | 8               | 1048                            | 3:30 p. m.         |
|     |                            | 30.73                     | 3.42                       | 100                        |                                                   |         |                |           |     |            |                 |                                 |                    |
|     |                            | Average                   | 3.42                       | 100                        | 204                                               | 24      | $7\frac{1}{4}$ | 15        | 3   | 39         | $10\frac{1}{4}$ | 1082                            |                    |

NOTE—The test was made with the pumping plant described on page five.

Table III—Test on Gasoline

Showing the results secured in two runs, using gasoline as fuel.

| No. | Length of run, hrs min. | Gallons gasoline consumed | Gallons gasoline consumed per hour | Per cent gasoline consumed | Speed revolutions per minute Engine Pump | Suction Ft. In.   | Discharge Ft. In. | Total Lift Ft. In. | Gallons water pumped per minute | Time reading taken |
|-----|-------------------------|---------------------------|------------------------------------|----------------------------|------------------------------------------|-------------------|-------------------|--------------------|---------------------------------|--------------------|
| 1   | 3-18                    |                           |                                    |                            | 204 588                                  | 25- $\frac{1}{4}$ | 15-3              | 40- $3\frac{3}{4}$ | 1083                            | 10:00 a. m.        |
| 2   | 2-35                    |                           |                                    |                            | 203 588                                  | 25- $\frac{1}{4}$ | 15-3              | 40- $3\frac{3}{4}$ | 1089                            | 11:00 a. m.        |
|     | 5-43                    | 18.82                     | 3.29                               | 100                        |                                          |                   |                   |                    |                                 |                    |
|     | Average                 |                           | 3.29                               | 100                        | 203.5 588                                | 25- $\frac{1}{4}$ | 15-3              | 40- $3\frac{3}{4}$ | 1086                            |                    |

NOTE The test was made with the pumping plant described on page five.

**Table IV—Relative Cost of Pumping**

Showing the cost of a ten hour and a twenty-four hour run on crude oil, kerosene and gasoline.

|                                                                               | CRUDE OIL. |      | 10 Hr. | 24 Hr.  |
|-------------------------------------------------------------------------------|------------|------|--------|---------|
|                                                                               |            |      | Run    | Run     |
| 30 minute run on gasoline to heat carburetor, 1.64-½ gallons @ 20 1-5 cts.... | \$         | .33  | \$     | .33     |
| 9-½ hours run on crude oil, 48.64 gallons @ 5 3-5 cents.....                  |            | 2.72 |        |         |
| 23-½ hours run on crude oil 120.32 gallons @ 5 3-5 cents.....                 |            |      |        | 6.74    |
| Total cost of fuel for running ten hours.....                                 | \$         | 3.05 |        |         |
| Total cost of fuel for running twenty-four hours.....                         |            |      |        | \$ 7.07 |
| <b>KEROSENE.</b>                                                              |            |      |        |         |
| 30 minute run on gasoline to heat carburetor, 1.64-½ gallons @ 20 1-5 cts.... | \$         | .33  | \$     | .33     |
| 9 ½ hours run on kerosene, 32.49 gallons @ 19 1-5 cents.....                  |            | 6.24 |        |         |
| 23-½ hours run on kerosene, 80.37 gallons @ 19 1-5 cents.....                 |            |      |        | 15.48   |
| Total cost of fuel for running ten hours.....                                 | \$         | 6.57 |        |         |
| Total cost of fuel for running twenty-four hours.....                         |            |      |        | \$15.76 |
| <b>GASOLINE.</b>                                                              |            |      |        |         |
| 10 hours run on gasoline, 32.90 gallons @ 20 1-5 cents.....                   | \$         | 6.65 |        |         |
| 24 hours run on gasoline, 78.96 gallons @ 20 1-5 cents.....                   |            |      |        | \$15.95 |
| Total cost of fuel for running ten hours.....                                 | \$         | 6.65 |        |         |
| Total cost of fuel for running twenty-four hours.....                         |            |      |        | \$15.95 |

**Table V—Relative Amount Water Pumped and Acres Irrigated**

Showing the average number of gallons pumped per minute, and the acres of land that can be irrigated to a depth of 2, 3, 4, 5 and 6 inches in 10 and 24 hours, when running on crude oil, kerosene and gasoline.

| Kind of Oil | Gallons pumped per minute Average | Acres irrigated in 10 hours |      |      |      |      | Acres irrigated in 24 hours |       |       |       |      |
|-------------|-----------------------------------|-----------------------------|------|------|------|------|-----------------------------|-------|-------|-------|------|
|             |                                   | Inches Deep                 |      |      |      |      | Inches Deep                 |       |       |       |      |
|             |                                   | 2                           | 3    | 4    | 5    | 6    | 2                           | 3     | 4     | 5     | 6    |
| Crude Oil   | 1088                              | 12.02                       | 8.01 | 6.01 | 4.81 | 4.01 | 28.85                       | 19.23 | 14.42 | 11.54 | 9.62 |
| Kerosene    | 1082                              | 11.95                       | 7.97 | 5.98 | 4.78 | 3.98 | 28.69                       | 19.13 | 14.35 | 11.48 | 9.56 |
| Gasoline    | 1096                              | 12.11                       | 8.07 | 6.05 | 4.84 | 4.04 | 29.06                       | 19.37 | 14.53 | 11.62 | 9.69 |

NOTE—The test was made with the pumping plant described on page five.

**Table VI—Relative Cost per Acre**

Showing the cost of fuel per acre to irrigate to a depth of 2, 3, 4, 5 and 6 inches, when running ten hours each day on crude oil, kerosene and gasoline.

| Kind of Oil    | Average number of gallons pumped per minute | INCHES DEEP |        |        |        |        |
|----------------|---------------------------------------------|-------------|--------|--------|--------|--------|
|                |                                             | 2           | 3      | 4      | 5      | 6      |
| Crude Oil..... | 1088                                        | \$ .25      | \$ .38 | \$ .51 | \$ .63 | \$ .76 |
| Kerosene.....  | 1082                                        | .55         | .82    | 1.10   | 1.37   | 1.65   |
| Gasoline.....  | 1096                                        | .55         | .82    | 1.10   | 1.37   | 1.65   |

NOTE—The test was made with the pumping plant described on page five.

**Table VII—Relative Amount and Cost of Fuel**

Showing the number of gallons of oil required and the cost of pumping 1, 10 and 24 hours with crude oil, kerosene and gasoline.

| KIND OF OIL    | Average number of gallons pumped per minute | Gallons consumed in |         |         | Cost of running |         |
|----------------|---------------------------------------------|---------------------|---------|---------|-----------------|---------|
|                |                                             | 1 hr.               | 10 hrs. | 24 hrs. | 10 hrs.         | 24 hrs. |
| Crude Oil..... | 1088                                        | 5.12                | 51.2    | 122.88  | 3.05*           | 7.07*   |
| Kerosene.....  | 1062                                        | 3.42                | 34.2    | 82.08   | 6.57*           | 15.76*  |
| Gasoline.....  | 1006                                        | 3.29                | 32.9    | 78.96   | 6.65            | 15.95   |

\*Including the cost of a thirty minute run on gasoline in order to heat the carburetor.  
 NOTE—The test was made with the pumping plant described on page five.

### THE USE OF CRUDE AND REFINED OILS

In view of the difference in the cost of pumping between crude oil and refined oil (whether kerosene or gasoline) the importance, from a financial standpoint, of the use of the former would seem to impress itself upon those who are seeking to cheapen the cost of pumping. Moreover, the probable discovery of profitable uses for the residue would further lend interest to this important question. If the unconsumed portion of the crude oil, after thorough trial, should prove to be a fair lubricant for ordinary bearings and its use as such were assured, the cost of operating on crude oil would be still further reduced. At an estimated value of 12½c per gallon, the residue thrown out by the carburetor would about equal the original cost of the oil. Furthermore, if the residue were sold for use on streets or roads, at ½c per gallon, the total cost of the fuel for pumping would be reduced by about 4 per cent,—an item in itself not to be ignored. The results obtained show that by the use of crude oil there is a saving, over the cost of pumping with kerosene or gasoline, of 53½ per cent and 54 per cent, respectively, without taking into consideration the value of the residue.

### ACKNOWLEDGEMENTS

Acknowledgement is due to the Fairbanks, Morse and Company, Denver, Colorado, for the loan of a 22 H. P. gasoline engine with a crude oil attachment, a No. 6 centrifugal pump, and the necessary fittings complete for setting up the outfit; and to the Atchison, Topeka and Santa Fe Railway for courtesies extended in connection with the experimental work.

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## BULLETIN NO. 54

MARCH 1905

New Mexico College of Agriculture and Mechanic Arts

AGRICULTURAL EXPERIMENT STATION

MESILLA PARK, N. M.

# SOIL MOISTURE INVESTIGATIONS FOR THE SEASON OF 1904



Soil Moisture Plats Referred to in this Bulletin

BY

J. D. TINSLEY and J. J. VERNON

SANTA FE, N. M.:  
THE NEW MEXICAN PRINTING COMPANY.  
1905.

# **NEW MEXICO AGRICULTURAL EXPERIMENT STATION**

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## SUMMARY AND CONCLUSIONS

1.—The high wind velocity, very low relative humidity of the air and very small amount of rain during the season caused great evaporation of moisture from the soil and probably exerted an injurious influence on the yield of the wheat, which was only about two thirds of the yield of the previous season.

2.—Irrigating oftener than once in three weeks after wheat begins to head increases the yield, but the increase is scarcely enough to pay for the application of the other irrigations.

3.—Twenty four inches of water gave the greatest yield per inch of water applied; and while 35 and 29 inches of water gave greater yields than did 24 inches, the increase per inch of water is very small. Twenty-four inches was the most economical amount.

4.—There is probably a certain moisture content of the soil, close to 25 per cent. in this soil, necessary for a good growth of straw and yield of grain; and beyond this, wheat is not very sensitive to increase in the moisture content of the soil.

5.—A difference of six inches of water received between the plats of series 1 and 2 was not indicated in the moisture results, but this amount of water gave appreciable differences between the moisture contents of the other series.

6.—Variations in texture and the irregular distribution of the water through the soil make it very difficult to obtain percentages of moisture which will express accurately the true moisture conditions of the soil; but these percentages afford valuable indications of the conditions especially in regard to percolation.

7.—The plats as a rule did not gain materially in moisture below the second foot during the season and there were indications of a general loss in total moisture toward the end of the season.

8.—There was no indication of an appreciable loss of moisture from the percolation into the soil below the limits of the roots of the wheat.

### INTRODUCTION

This bulletin embraces the results of the cooperative experiments between the Departments of Agriculture and Soils, on Soil Moisture for the season of 1904. The results of previous years were reported in bulletins Nos. 31, 38, 46, and 48 of this station.

The plats were sown to wheat again this season, although they were in wheat the previous year.

The subjects investigated were nearly the same as those studied last season and were:

- 1.—To learn the effects of different numbers of irrigations on the yield of wheat, especially the effects of different numbers of irrigations applied between the time that the wheat began to head and until it was almost ripe.

- 2.—The relations between the number of irrigations, the amount of moisture in the soil and the yield.

- 3.—The relations between the amount of water applied, the soil moisture and the yield.

- 4.—The distribution of the soil moisture in depth and the amount of percolation.

The Department of Agriculture had charge of the sowing, observations on growth, harvesting, threshing and weighing up the yield. The Department of Soils superintended the irrigating, took the moisture samples and determined the moisture.

Mr. J. M. Scott superintended the work for the Department of Agriculture and Mr. R. H. Hart, student assistant in Soils, rendered valuable assistance in the sampling and moisture determinations.

### PLAN OF THE EXPERIMENTS

The results of 1903 indicated that the application of water while wheat was heading and filling was more beneficial than its application before this time, and the experiments this year were designed to test this point further. From the experience of the previous year, it was thought that once a week after the wheat began to head was often enough for the most frequent irrigations. In order to have as many plats as possible in duplicate, it was decided to try irrigating once a week, once in two weeks, and once in three weeks after the wheat began to head.

**LOCATION.**—The land used for these experiments was that which has been used for the moisture work since 1901.

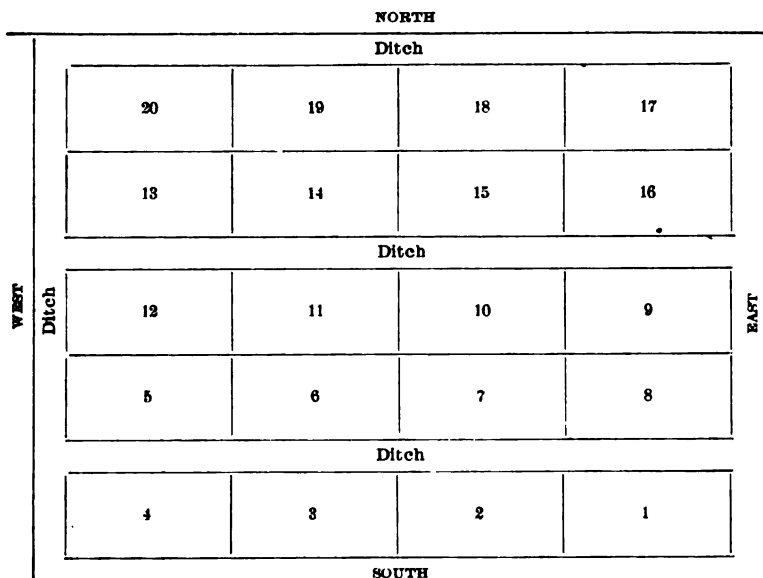
It was decided to decrease the number of plats and make them practically uniform in area. In order to do this, and allow for the necessary borders and ditches, it was necessary to take in some additional land. This was done by adding a strip about fifty feet wide on the north side and one about forty feet wide on the south. This area, about 430 feet east to west by 290 feet north to south, was divided into twenty plats. The area of each plat was approximately one-tenth acre, except the row on the north side in which the plats were slightly larger.

Borders high enough to hold the water used in flooding the plats were thrown up between them.

**DITCHES.**—The ditches were placed so that each plat could be irrigated independently of the others.

Frames 30 inches long by 12 inches high, with sliding gates, were placed in the sides of the ditches, one to each plat, for letting in the water.

The arrangement of the plats and ditches is shown in the accompanying diagram.



**IRRIGATION.**—All of the plats were to be irrigated soon after sowing; again when they were beginning their spring growth, about the middle of April; and for the third time when they began to head, about the middle of May. After this third irrigation plats 2, 6, 9, 12, 13, 17 were to be irrigated once each week; plats 4, 7, 11, 15, 16 and 19 were to be irrigated once in two weeks; and plats 3, 5, 10, 14, 18, and 20 were to be irrigated once in three weeks.

Plats 1 and 8 were higher than the others and therefore difficult to irrigate uniformly; so these were left for trying the effects of a smaller amount of water.

The results of 1903 showed that some parts of this land gave better yields than others; therefore, instead of making up the series from adjacent plats they were made up of alternating plats.

Because of the great variability in the productive capacity of this soil, it is very necessary to have as many repeaters as possible.

#### MOISTURE DETERMINATIONS

As in the previous season, all of the samples were taken with augers worked through a guard tube. The samples were taken in one foot sections to a depth of six feet. They were taken to that depth in order to find out how far down the irrigating water percolated.

The samples were taken one or two days before irrigation and as soon thereafter as the surface was dry enough to admit walking on, usually five days after the water was applied. This system, of course gave only one sampling to the irrigation on the plats irrigated once a week.

The moisture was determined from the loss in weight on drying at about 110-115 degrees C for several hours.

All the percentages of moisture in this bulletin are expressed in terms of the dry soil. For example, 25 per cent of moisture means that for every 100 parts of dry soil there are 25 parts of water.

#### SEEDING AND HARVESTING

The ground was plowed and put in condition for seeding early in December, 1903. The same variety of wheat was used as last year,—Algerian White, Station No. 410. This is a bearded variety with large white kernels and heavy straw. It was sown on December 22nd, 1903, at the rate of 2 bushels per acre with a

press drill, from 1 1-2 to 2 inches deep, the drills being 8 inches apart. The wheat was harvested with a Champion selfbinder on June 25th. The grain was standing up well over all the field, and, therefore, there was little waste of grain in harvesting.

It was threshed with a three horse-power machine. The machine was cleaned after running through the product of each plat.

### IRRIGATION

All of the irrigations were carried out as planned. The first was given on January 5th and was with river water; the second was given on April 19th, this and all succeeding irrigations were with pump water from the Station pumping plant; the third was given on May 18th and after this time they were given once a week, once in two weeks, and once in three weeks according to the schedule until June 15th, when the wheat of all the plats was ripening.

MEASUREMENT OF THE WATER.—The river water for the first irrigation was measured over a two foot trapezoidal (Cippoletti) weir, the depth over the crest of the weir being measured and recorded by a Standard Water Register. The pen of this register moves an inch in an hour and thus measures slight fluctuations in the height in short intervals of time. This weir is located one hundred and ninety yards west of the plats.

For the second and all succeeding irrigations, for which pump water was used, the pump was speeded to throw 1,000 gallons per minute, and this speed was maintained as carefully as possible throughout the run. This water was run over a six foot trapezoidal (Cippoletti) weir (see plate 1) and the depth over the crest was measured with a hook gauge. The gauge was read frequently to see that the flow remained constant. This weir is located about 500 yards from the plats and after the water left it, there was no further check on the quantity. The loss by seepage from the ditch is, therefore, not known; but, so far as we could observe, it was very little.

The area of each of the plats was measured and the time that would be required by a stream of 1,000 gallons per minute to give several depths of water in inches on it was calculated.

The water was allowed to fill the ditch to the height on the gate of each plat at which it stood while flowing into the plat. The gate was then opened and the water allowed to flow in for the cal-

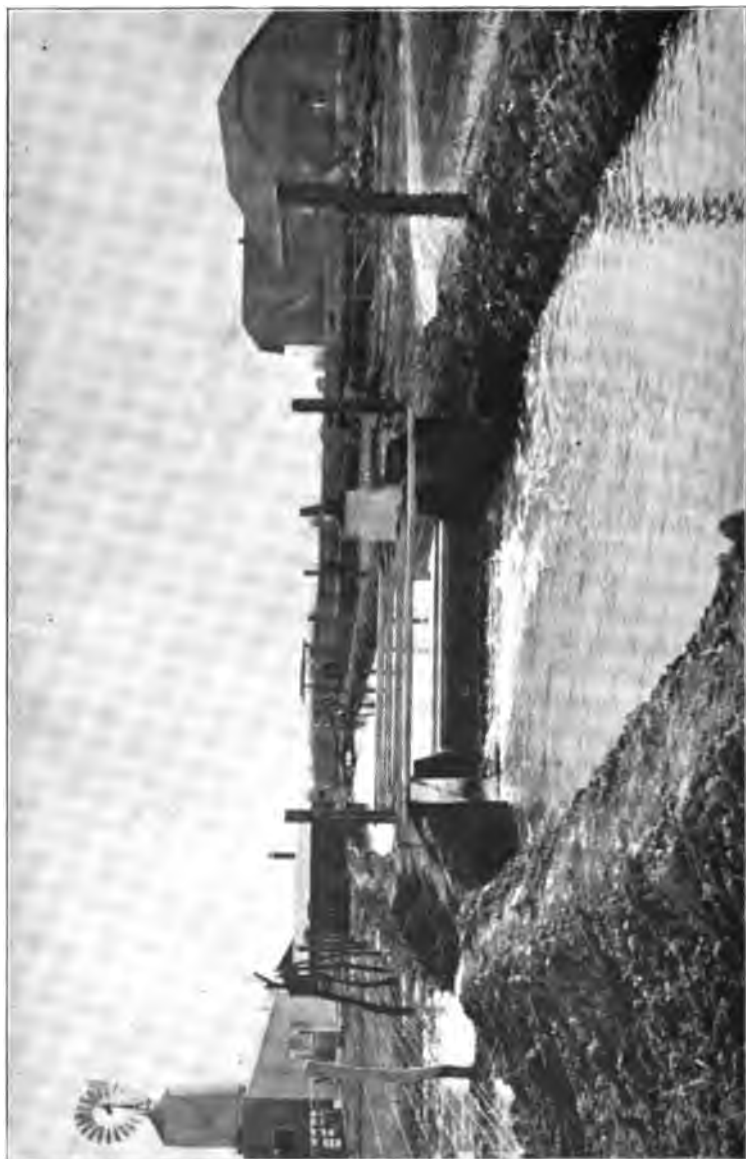


PLATE 1.—Six-foot Cippoletti Weir, with hook gauge on the left and water register on the right

culated length of time. This method is, of course, not extremely accurate but we believe that it gives a fair approximation to the amount of water applied.

**AMOUNT OF WATER.**—In the first irrigation the plats were flooded according to the judgment of a Mexican irrigator and only the total amount used on all of the plats was calculated. It was assumed that each plat received the same amount. The quantity used was sufficient to flood the entire area of the plats to a depth of six inches.

The depths given in this bulletin are those at which the water would have stood over the given area if none of it had soaked into the ground or evaporated. They do not mean, for example, that the water stood six inches after the plats were irrigated.

**Table 1.—Amount of Water Applied.**  
Depth in Inches.

| Irrigated once a week after Heading. |          |    |    |    |    |    |
|--------------------------------------|----------|----|----|----|----|----|
| Date<br>1904                         | Plat No. |    |    |    |    |    |
|                                      | 2        | 6  | 9  | 12 | 13 | 17 |
| January 5                            | 6        | 6  | 6  | 6  | 6  | 6  |
| April 19                             | 6        | 6  | 6  | 6  | 6  | 6  |
| May 18                               | 6        | 6  | 6  | 6  | 6  | 6  |
| May 25                               | 5        | 5  | 5  | 5  | 5  | 5  |
| June 2                               | 4        | 4  | 4  | 4  | 4  | 6  |
| June 8                               | 4        | 4  | 4  | 4  | 4  | 4  |
| June 15                              | 4        | 4  | 4  | 4  | 4  | 4  |
| Total.....                           | 35       | 35 | 35 | 35 | 35 | 37 |

| Irrigated once in two weeks after Heading. |          |    |    |    |    |    |
|--------------------------------------------|----------|----|----|----|----|----|
| Date<br>1904                               | Plat No. |    |    |    |    |    |
|                                            | 4        | 7  | 11 | 15 | 16 | 19 |
| January 5                                  | 6        | 6  | 6  | 6  | 6  | 6  |
| April 19                                   | 6        | 6  | 6  | 6  | 6  | 6  |
| May 18                                     | 6        | 6  | 6  | 6  | 6  | 6  |
| June 2                                     | 6        | 6  | 6  | 6  | 6  | 6  |
| June 15                                    | 5        | 5  | 6  | 5  | 5  | 5  |
| Total.....                                 | 29       | 29 | 30 | 29 | 29 | 29 |

**Table 1.—Amount of Water Applied.—Continued.**

| Date<br>1904 |    | Irrigated once in three weeks after Heading. |    |    |    |    |    |
|--------------|----|----------------------------------------------|----|----|----|----|----|
|              |    | Plat No.                                     |    |    |    |    |    |
|              |    | 3                                            | 5  | 10 | 14 | 18 | 20 |
| January      | 5  | 6                                            | 6  | 6  | 6  | 6  | 6  |
| April        | 19 | 6                                            | 6  | 6  | 6  | 6  | 6  |
| May          | 18 | 6                                            | 6  | 6  | 6  | 6  | 6  |
| June         | 8  | 6                                            | 6  | 6  | 6  | 6  | 6  |
| Total.....   |    | 24                                           | 24 | 24 | 24 | 24 | 24 |

Depth in Inches.

| Date<br>1904 |    | Not Irrigated during Heading. |    |
|--------------|----|-------------------------------|----|
|              |    | Plat No.                      |    |
|              |    | 1                             | 8  |
| January      | 5  | 6                             | 6  |
| April        | 19 | 6                             | 6  |
| May          | 19 | 6                             | 6  |
| Total.....   |    | 18                            | 18 |

Table 1 gives the dates of the irrigations and the depths of water given at each.

Plat 17, 18, or 19 was irrigated first each time and the amount of water necessary to flood it well all over was used on each of the other plats in the series, with two exceptions. On June 2nd, 6 inches were required to wet plat 17 well, while 4 inches were sufficient for the other plats of this series. On June 15th, plat 11 was given an additional inch by mistake.

The second irrigation of plat 17 may be taken as an illustration of the method of finding out the amount of water necessary for the irrigation of a plat. When 3 inches had run in, the water had gone over less than half of the plat; another inch was added and this (4 inches) did not get entirely over, so another was added, and the five inches barely wet the highest places; another inch was then added making six inches in all. This amount was then given to each of the other plats of this series, and on those on the south side, the water stood 3 or 4 inches deep in the lower places.



The surface of the soil of all of the plats was considerably cracked from before the time of the second irrigation until the end of the season. The size of the cracks varied with the texture of the soil. The south side of the area is clay loam to light clay and the cracks here were not so large nor so deep as on the north side which is clay to heavy clay.

Plate 2, from a similar soil planted to alfalfa, gives a good idea of the cracks in the north row of the plats. The rule is six inches long.

These cracks allow the water to get down into this heavy soil and wet it more readily than if it had to percolate through an unbroken surface. On the other hand, they tend to make the distribution of the water uneven.

#### METEOROLOGICAL CONDITIONS OF THE SEASON

In the following table will be found the mean temperature, mean relative humidity, average wind velocity per hour and amount of rain for each month from the time that the wheat was sown until it was cut. In order to bring out more clearly the conditions which prevailed during the season, the averages for the same months of the six preceding years are given.

The mean temperatures were obtained by taking the average of the maximum and minimum temperatures for each day of the month and averaging these.

By relative humidity is meant the percentage of moisture present of the total amount that the air could hold at that temperature. For example, if the relative humidity of the air is 50 per cent. that means that there is only one half as much moisture in the air at that time as there would be if the air contained all of the moisture that it could hold at that temperature. The percentages of relative humidity are the mean of the morning and evening observations for each day averaged for each month.

The wind velocities were obtained by dividing the total wind movement in miles for each month by the number of hours in the month.

The rain is the average of the total rainfall for each month.

The rate of evaporation from the surface of the soil, or from a water surface, depends upon the wind velocity, relative humidity of the air and temperature. At the ordinary temperatures of the growing season the rate of evaporation is probably influenced most



PLATE 2.—Cracks in a heavy clay (adobe) soil.

by the wind and increases rapidly with increased wind velocity. Relative humidity is also a very important factor since the drier the air, lower the relative humidity, the more rapid will be the evaporation.

Table 2.—Meteorological Data

|                    | Mean Temperature,<br>F° |      | Relative Humidity, Mean,<br>Per Cent. |      | Wind Velocity<br>Av. Miles per hour. |      | Rain      |      |
|--------------------|-------------------------|------|---------------------------------------|------|--------------------------------------|------|-----------|------|
|                    | 1898-1903               | 1904 | 1898-1903                             | 1904 | 1898-1903                            | 1904 | 1897-1903 | 1904 |
| January            | 41.5                    | 37.8 | 47.0                                  | 23.0 | 6.1                                  | 6.9  | .20       | .00  |
| February           | 44.8                    | 48.0 | 45.3                                  | 25.3 | 8.0                                  | 7.3  | .45       | .11  |
| March              | 50.9                    | 55.9 | 38.5                                  | 14.1 | 9.3                                  | 10.0 | .46       | .00  |
| April              | 58.5                    | 57.5 | 35.3                                  | 13.3 | 9.3                                  | 9.9  | .25       | .00  |
| May                | 66.1                    | 68.0 | 36.9                                  | 18.0 | 8.7                                  | 9.5  | .16       | .05  |
| June               | 74.7                    | 76.9 | 38.0                                  | 25.1 | 7.3                                  | 9.9  | 1.24      | .70  |
| Average for season | 56.1                    | 57.4 | 40.1                                  | 19.8 | 8.1                                  | 8.9  | *2.76     | *.86 |

\*Total instead of average.

In the following table the average mean temperature, relative humidity, wind velocity and total rainfall are given for January to June inclusive, for each year together with the final averages for comparison with the conditions of 1904.

Table 3.—Meteorological Data.

| Year .....            | 1898 | 1899 | 1900 | 1901 | 1902 | 1903 | Average | 1904 |
|-----------------------|------|------|------|------|------|------|---------|------|
| Mean Temperature      | 54.7 | 53.5 | 58.0 | 57.1 | 58.0 | 55.0 | 56.1    | 57.4 |
| Relative Humidity..   | 60.8 | 48.3 | 42.8 | 30.6 | 22.0 | 36.3 | 40.1    | 19.8 |
| Wind, Av. vel. p. hr. | 7.1  | 7.8  | 8.2  | 8.6  | 8.3  | 8.5  | 8.1     | 8.9  |
| Rain, Total.....      | 3.25 | 1.25 | 3.46 | 3.20 | .20  | 5.22 | 2.76    | .86  |

These tables show that the conditions were more favorable to evaporation during this season than they were in any of the six preceding years.

There were two years, 1900 and 1902, with a slightly higher

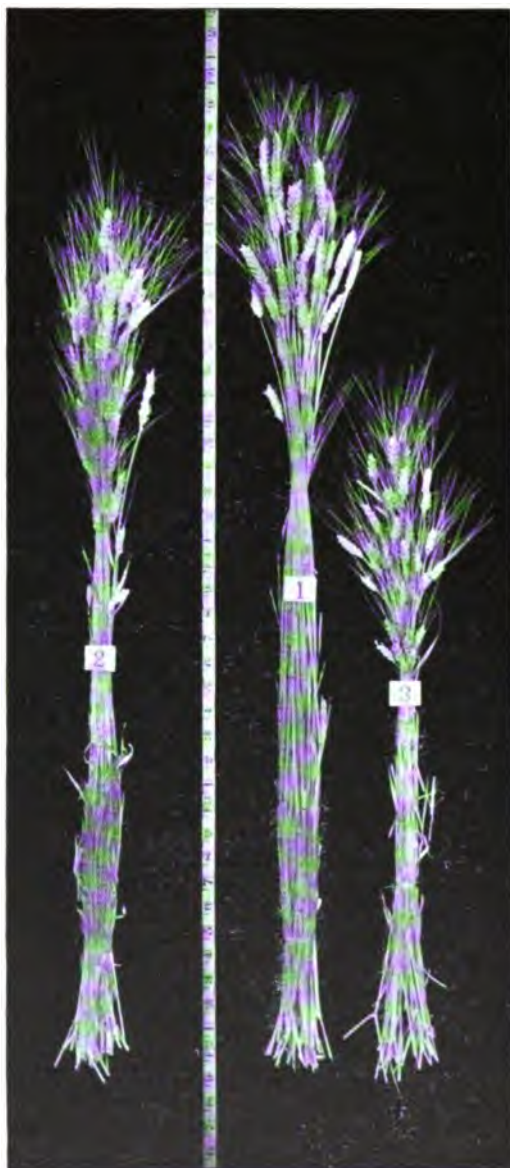


PLATE 3.—Samples showing the average best (No. 1), average (No. 2), and average poorest (No. 3) of the wheat.

mean temperature but in 1904 the temperature was above the average.

The relative humidity was much lower than in any year except 1902 and was only half the average.

The average hourly velocity of the wind was higher than in any of the preceding years and was nearly a mile an hour above the average. While there were fewer storms than usual during this period in 1904, the wind maintained a more constant high velocity as is shown by the high average for each month.

The rainfall was much less than in any year except 1902, being about half that of 1899, and less than one third of the average. Of the .70 inch of rain in June, .55 inch fell after the wheat was cut and exerted no influence on the crop; but as the moisture samples of the last sampling were not taken until a few days after the rain, it may have increased the moisture content of the samples by a slight amount. The amount of rain during the season was so small that it has not been considered in the discussions of the amounts of water received by the crop.

These conditions not only caused a great loss of moisture from the soil but they also probably exerted an injurious action on the growth and yield of the wheat. The yields per acre for this season are only about two thirds of those of the previous year and that this decrease is probably not altogether due to soil conditions is indicated by the fact that other experimental plats of wheat on the station farm gave yields that were 10 to 20 per cent. less than the yields of the same varieties in 1903.

#### NOTES ON THE CONDITION OF THE CROP

The following notes show the general condition of the crop during the growing season.

April 1.—Good even stand on all of the plats. Rabbits pasturing on plats 1 to 8 but this will probably not affect the wheat materially.

May 2.—No apparent difference in the wheat on the various plats. Effect of the rabbits practically overcome.

May 25.—All plats heading and some heads beginning to bloom.

June 1.—Beginning to fill.

June 8.—Grain almost full size—watery stage.

June 15.—Grain full size—milk stage.

June 22.—Grain dough stage—taking on lighter color—beginning to ripen.

Plate 3 shows three samples of the wheat cut off close to the ground, taken at the time of harvesting. No. 1 is the average of the tallest on the plats and was about 4 feet 2 inches high. No. 2 was about the average height of the best, which was about 3 feet 6 inches. No. 3 was an average of the poorest on any of the plats and was about 2 feet 10 inches high.

The tallest of all was on a portion of plat 9 and this was about 4 feet 10 inches high.

#### **EFFECT ON THE YIELD, OF DIFFERENT NUMBERS OF IRRIGATIONS AFTER WHEAT BEGINS TO HEAD.**

In table 4 the plats are arranged in series according to the frequency of irrigations. The yields of grain are calculated from the weights to bushels per acre (60 lbs. equal 1 bushel) and the straw to pounds per acre.

For the sake of brevity the plats irrigated once a week after heading will be referred to as series 1; those irrigated once in two weeks, as series 2; those irrigated once in three weeks, as series 3; and those not irrigated after it began to head, as series 4.

The highest yield of grain (25.8 bu.) is found in series 1 and the lowest (8.8 bu.) in series 4. One of the lowest (13.2 bu.) is found in series 1 and two high yields in series 2. Series 1 averages 1.4 bu. more than series 2. This average is, however, raised materially by the high yield of plat 17. If we exclude plat 17 the average for series 1 falls to 16.5 bu., a little below that of series 2.

Series 1 and 2 average higher than series 3, but four of the plats in series 3 average nearly as high (16.3 bu.) as either series 1 or 2; and if plat 20 is excluded, the average for series 3 rises to 15.7 bu. The reason for excluding plat 20 is that the surface soil is very heavy and its mechanical condition is such that very little water went below the surface foot. In this respect it differed from all of the other plats.

Series 4 averages considerably below the others, yet plat 20 yielded less than plat 3.

Excluding plat 17 from series 1 and plat 20 from series 3, the yields are as follows: Series 2, 16.6 bu.; series 1, 16.5 bu.; series 3, 15.7 bu.; and series 4, 10.6 bu.

These results lead to the conclusion that on these plats there is no decided advantage in irrigating oftener than once in three weeks after the wheat begins to head.

**Table 4.—Number of Irrigations, Amount of Water, Moisture Content and Yield.**

| Plat<br>Num-<br>ber.                         | Yield                      |                           | Average Percentage of Moisture |        |        |        | Depth of<br>water<br>applied in<br>inches |
|----------------------------------------------|----------------------------|---------------------------|--------------------------------|--------|--------|--------|-------------------------------------------|
|                                              | Grain, Bushels<br>per Acre | Straw, Pounds<br>per Acre | in                             |        |        |        |                                           |
|                                              |                            |                           | 2 feet                         | 3 feet | 4 feet | 6 feet |                                           |
| Irrigated once a week after heading.         |                            |                           |                                |        |        |        |                                           |
| 2                                            | 17.5                       | 1898                      | 24.7                           | 22.8   | 20.1   | 14.7   | 35                                        |
| 6                                            | 14.9                       | 1315                      | 25.8                           | 24.2   | 22.9   | 17.6   | 35                                        |
| 9                                            | 19.5                       | 3645                      | 27.7                           | 24.9   | 23.9   | 18.1   | 35                                        |
| 12                                           | 18.2                       | 1368                      | 24.4                           | 22.1   | 19.9   | 14.8   | 35                                        |
| 13                                           | 17.2                       | 1818                      | 25.0                           | 20.9   | 17.7   | 13.1   | 35                                        |
| 17                                           | 25.8                       | 1640                      | 31.4                           | 29.1   | 27.2   | 20.0   | 37                                        |
| Average                                      | 18.0                       | 1947                      | 26.5                           | 24.0   | 21.9   | 16.4   | 35.3                                      |
| Irrigated once in two weeks after heading.   |                            |                           |                                |        |        |        |                                           |
| 4                                            | 14.3                       | 1506                      | 26.5                           | 27.4   | 26.4   | 19.9   | 29                                        |
| 7                                            | 16.6                       | 1540                      | 21.6                           | 20.0   | 18.6   | 14.6   | 29                                        |
| 11                                           | 14.1                       | 1251                      | 24.8                           | 22.3   | 21.3   | 16.3   | 30                                        |
| 15                                           | 21.2                       | 2430                      | 28.5                           | 24.4   | 21.8   | 16.7   | 29                                        |
| 16                                           | 20.0                       | 3280                      | 29.0                           | 25.3   | 23.3   | 18.5   | 29                                        |
| 19                                           | 13.8                       | 1400                      | 28.8                           | 25.3   | 21.9   | 16.1   | 29                                        |
| Average                                      | 16.6                       | 1901                      | 26.9                           | 24.1   | 22.2   | 17.0   | 29.2                                      |
| Irrigated once in three weeks after heading. |                            |                           |                                |        |        |        |                                           |
| 3                                            | 16.5                       | 1953                      | 26.4                           | 23.9   | 22.2   | 17.7   | 24                                        |
| 5                                            | 16.4                       | 1517                      | 24.8                           | 21.4   | 20.9   | 16.6   | 24                                        |
| 10                                           | 13.6                       | 1203                      | 23.9                           | 21.1   | 18.0   | 13.9   | 24                                        |
| 14                                           | 16.2                       | 1421                      | 26.2                           | 23.5   | 19.7   | 14.5   | 24                                        |
| 18                                           | 16.0                       | 1561                      | 29.3                           | 26.0   | 21.7   | 15.6   | 24                                        |
| 20                                           | 11.7                       | 1016                      | 20.1                           | 17.3   | 15.1   | 11.3   | 24                                        |
| Average                                      | 15.1                       | 1450                      | 25.1                           | 22.2   | 19.6   | 14.9   | 24                                        |
| Not Irrigated after heading.                 |                            |                           |                                |        |        |        |                                           |
| 1                                            | 8.8                        | 968                       | 18.9                           | 17.2   | 15.6   | 11.6   | 18                                        |
| 8                                            | 12.5                       | 1421                      | 23.6                           | 20.5   | 17.9   | 14.5   | 18                                        |
| Average                                      | 10.6                       | 1207                      | 21.2                           | 18.9   | 16.8   | 13.1   | 18                                        |

### RELATIONS BETWEEN THE NUMBER OF IRRIGATIONS, SOIL MOISTURE AND YIELD.

In table 4, in addition to the yields, the average percentages of moisture for the season in each plat are given, not only for the first

two feet, as in Bul. 48, but for the first three, first four, and first six feet of the soil.

Plat 17 with the highest percentage of moisture (31.4) gave the highest yield and plat 1 with the lowest (18.9) gave the lowest yield. Plats 15 and 16 with 28.5 and 29.0 per cent. also gave high yields while plat 19 with 28.8 per cent. gave one of the lowest yields.

In considering the individual plats we fail to find any close relation between the amount of soil moisture and the yield.

Taking the averages of the series, we find series 1 with a little less moisture than series 2 and a slightly greater yield and series 3 with slightly less moisture and a smaller yield than either 1 or 2. If we again exclude plats 17 and 20 from this series, the moisture content and yields stand as follows: Series 2, average percentage of moisture in first two feet 26.9, average yield 16.6 bu.; series 1, moisture 25.5 per cent., yield 16.3 bu.; series 3, moisture 26.1 per cent., yield 15.7 bu.; and series 4, moisture 21.2 per cent., yield 10.6 bu. The results for series 3 are irregular and we have to conclude that there is little if any correspondence between soil moisture and yield within narrow limits of moisture.

**Table 5.—Yield, Moisture Content and Amount of Water. Plats Grouped According to Yield.**

| Yield                                                               |                       | Average percentage of moisture |        |        |        | Depth of water applied in inches |
|---------------------------------------------------------------------|-----------------------|--------------------------------|--------|--------|--------|----------------------------------|
| Grain Bushels Per Acre                                              | Straw Pounds Per Acre | in                             |        |        |        |                                  |
|                                                                     |                       | 2 feet                         | 3 feet | 4 feet | 6 feet |                                  |
| Group 1.—Yield 25 – 26 bushels per acre. Plat 17.                   |                       |                                |        |        |        |                                  |
| Average 25.8                                                        | 1640                  | 31.4                           | 29.1   | 27.2   | 20.0   | 37                               |
| Group 2.—Yield 19 -- 22 bu. per acre. Plats 9, 15, and 16.          |                       |                                |        |        |        |                                  |
| Average 20.2                                                        | 3118                  | 28.4                           | 24.9   | 23.0   | 17.8   | 31                               |
| Group 3.—Yield 16 – 18 bu. per acre. Plats 2, 3, 5, 13, 14, and 18. |                       |                                |        |        |        |                                  |
| Average 16.6                                                        | 1673                  | 25.4                           | 22.6   | 20.1   | 15.2   | 28                               |
| Group 4.—Yield 13 – 15 bu. per acre Plat 4, 6, 10, 11, 12, and 19.  |                       |                                |        |        |        |                                  |
| Average 14.0                                                        | 1340                  | 26.0                           | 23.7   | 21.7   | 16.4   | 30.3                             |
| Group 5.—Yield 8 – 12.5 bu. per acre. Plats 1, 8, and 20.           |                       |                                |        |        |        |                                  |
| Average 11                                                          | 1153                  | 20.8                           | 18.3   | 16.2   | 12.5   | 20                               |



In table 5 the plats have been divided into five groups according to their yields, and the average yield, average moisture content of the different depths, and average depth of water applied are given for each group.

The yields decrease with the amount of moisture, except group 4 which though having a little more moisture than group 3, has a yield of 2.4 bu. less.

These results tend to verify the conclusion that the yield does not correspond closely with the amount of moisture.

In tables 4 and 5 the yields of straw are found to agree with the yields of grain rather than with the amount of moisture, except for plat 17 where the amount of straw is small in proportion to that of grain.

On comparing the yields of the plats of 1903 with the yields of those occupying practically the same ground this year, it is found that the soil which gave the best yields the previous year also gave the best this season, and the poorest last season, the poorest this. These results tend to confirm the conclusions drawn last season "that for wheat the yield is more intimately connected with other factors than with soil moisture."

#### **RELATIONS BETWEEN THE AMOUNT OF WATER APPLIED, SOIL MOISTURE AND YIELD.**

On comparing series 1 and 2, table 4, it is found that 29.2 inches of water gave .4 per cent. more moisture in the first two feet of the soil of series 2 than did 35.3 inches for series 1, and series 2 shows more moisture at each depth than series 1. Series 3 received 5.2 inches less water than series 2 and shows 1.8 per cent. less moisture in the first two feet and also less at the other depths.

If we omit plats 17 and 20 from the averages of their series the differences are greater. Then series 1 which received 35 inches of water had 25.5 per cent. of moisture; series 2, 29.2 inches of water, 26.9 per cent. moisture; series 3, 24 inches of water, 26.1 per cent. of moisture. Twenty-four inches of water on series 3 gave .8 per cent. less moisture than 29.2 in. of water on series 2 and .6 per cent. more moisture than 35 in. on series 1.

Considering the yield, omitting plats 17 and 20, 24 in. water gave .6 bu. less than 35 in. and .9 bu. less than 29.2 in. Taking the yields as given in table 2, including plats 17 and 20, we find that

24 in. water gave 1.5 bu. less than 29.2 in. and 2.9 bu. less than 35.3 in.

Series 4 is scarcely comparable with the others as the lay of the land made the distribution of the water very irregular, and it is doubtful if one sample for each of these plats represents a fair average. Taking the results found for this series, they received 6 inches of water less than series 3, containing 3.9 per cent. less moisture and yielded 4.5 bu. less of grain.

The variations in the yields relative to the amount of water used are further emphasized in the following table in which the yields in bu. per acre for 1 inch of water are given. The numbers were obtained by dividing the yield of each plat by the number of inches of water used on that plat.

**Table 6.—Yield in bu. per Acre of Grain for 1 Inch of Water.**

| Series 1. |     | Series 2. |     | Series 3. |     | Series 4. |     |
|-----------|-----|-----------|-----|-----------|-----|-----------|-----|
| Plat      | Bu. | Plat      | Bu. | Plat      | Bu. | Plat      | Bu. |
| 2         | .50 | 4         | .49 | 3         | .69 | 1         | .49 |
| 6         | .43 | 7         | .57 | 5         | .68 | 8         | .70 |
| 9         | .56 | 11        | .47 | 10        | .57 |           |     |
| 12        | .38 | 15        | .73 | 14        | .68 |           |     |
| 13        | .49 | 16        | .69 | 18        | .67 |           |     |
| 17        | .70 | 19        | .48 | 20        | .49 |           |     |
|           | —   |           | —   |           | —   |           | —   |
| Av.       | .51 | Av.       | .57 | Av.       | .63 | Av.       | .59 |

Series 3 is the most uniform, if plat 20 is omitted, and gave the highest average yield. Series 4 comes next in average yield but there is a great difference between the yields of the two plats. Plat 8 gave as high a yield for the water used as plat 17 of series 1 although the actual yield of plat 17 was about twice as great as that of plat 8. Series 2 gave the next highest average yield but there is much variation between the yields of the plats. Plat 15 of this series gave the highest yield per inch of water of any of the plats but its actual yield was 4.6 bu. less than that of plat 17. Series 1 gave the lowest yield per inch of water and has the greatest variation among its plats. Plat 12 gave the lowest and plat 17 the highest yield of all.

Series 1 Illustrates very clearly the great differences which may occur in the yields from soils which receive practically the same amount of water and further emphasizes the fact that the soil moisture is only one of the factors influencing the yield of crops.

The increase in yield for this season for the amount of water used above 24 inches would scarcely have paid for the cost of the extra irrigations if river water had been used and it would have been produced at a loss if the water had been pumped.

The question naturally suggests itself, why did not the six inches more of water applied to series 1 than to series 2 raise the moisture content of series 1 above that of series 2? There may be several reasons for this.

The first reason lies in the irregular distribution of the water over the plats in irrigating. It is practically impossible when working under field conditions to make the surface of the plats uniform and, of course, the lowest places receive the most water. Then, too, inequalities in the texture and mechanical condition of the soil cause the water to be absorbed irregularly, making some spots more moist than others. These irregularities in texture and mechanical condition also influence capillarity or the rate at which water moves to the surface to supply that lost by evaporation. Irregular distribution of the roots of the crop, taking more water from some spots than others may have an influence on the distribution of the moisture. These are some of the reasons why certain spots in a plat are more moist than others.

The time that can be devoted to these experiments makes it practically impossible to take more than one six foot sample from each of these plats at the time of sampling. This sample is taken to represent as nearly an average as the person sampling can judge; it is usually taken from near the center of the plat, but there are many chances against this sample being an absolute average. These errors are partially eliminated in averaging the results for each plat for the season, as the moisture content of any single sample is probably as likely to be above the average as below it, and are further reduced in the final average for the series of plats.

Another reason lies in the variations in texture and mechanical condition of the different plats. The capacity of the soil of some of the plats to absorb water is considerably greater than that of others.

Still another reason is to be found in the amount of water ap-

plied at an irrigation. In series 2 and 3 six inches of water was applied each time, with one exception, while in series 1 the fourth irrigation was 5 inches and the last three 4 inches.

Previous experiments made here have shown that the rate of loss of water from the upper six inches of a soil is proportional to the amount of water present. For example, a fairly saturated soil containing 48 per cent. of moisture will lose 12 per cent., one fourth, of its moisture more rapidly than it loses the next 12 per cent. This being true, the plats receiving the lighter and more frequent irrigations would lose by evaporation a greater percentage of the water applied than would those receiving the heavier and less frequent irrigations which went deeper into the soil.

Other experiments now in progress on the irrigation of alfalfa tend to confirm the idea that less frequent heavy irrigations, for fairly deep rooted crops, are more economical both in soil moisture and cost than are more frequent light ones.

The evaporation from the surface of wet soil was exceptionally great this season because of an unusually large number of high, dry winds.

All of the plats would have shown higher average percentages of moisture if they had been sampled sooner after irrigation, and this difference would have been most marked in the averages of series 1 where it would probably have amounted to 2 or 3 per cent. and brought the moisture content of this series above that of the others.

These numbers must not be taken too literally, for it is here, that the unequal distribution of the moisture and the influence of the texture are most marked in their effect on the numerical results. For example, some sets of samples showed that those taken after irrigation were from spots that must have been very much drier before irrigation than the spots from which the samples before irrigation were actually taken. Again, where a one-foot sample passed through two layers of different texture, one layer loam and the other sand, more of the heavy material was included in one sample than in another and because of this one showed a higher moisture content than the other.

**CHANGES IN MOISTURE CONTENT AT DIFFERENT DEPTHS DUE TO PERCOLATION AND CAPILLARITY**

In the following table an attempt has been made at showing the movement of the moisture down through the soil. The movement depends mainly upon the texture of the soil as this controls the amount of water held by the soil as well as the rate at which the water moves through it. Heavy clay holds the greatest percentage of moisture per unit volume or weight and it allows water to pass through it most slowly because of the minuteness of the spaces between its small grains. Loams on the other hand are composed of much larger grains, have much larger spaces between the grains and therefore allow water to pass through them much more readily than do the clays. The total amount of pore space in clays is greater than that in loams, although the pores in the loams are the larger; and this together with the fact that the total area of the grains in a given volume or weight of clay is much greater than the total area of the grains in the same volume or weight of loam, explains why clays can hold so much more moisture than loams, Loams hold more moisture and allow it to pass through them less freely than do sands, for the above stated reasons.

Because of the close relations between texture and moisture content the texture of each foot is given in the table. The names of the textures have been abbreviated and the following symbols are used: Clay, C; clay loam, SCC; loam, SC; sandy loam, SSC; sand, S; h in a symbol means heavy, e. g. SCCh means heavy clay loam; the plus sign shows that material of both textures is found in that foot.

The numbers in this table have been obtained by taking the average of the percentages of moisture in each foot before irrigation and subtracting them from the average percentages found in each foot after irrigation. The — sign before a number indicates that the average amount of moisture found before irrigation was greater than that found after irrigation.

Table 7.—Average Gain or Loss in Moisture During the Season.

| Depth.                                                                                                      | Texture. | Moisture per cent. | Texture. | Moisture per cent. | Texture. | Moisture per cent. | Texture. | Moisture per cent. | Texture. | Moisture per cent. | Texture. | Moisture per cent. | Average. |
|-------------------------------------------------------------------------------------------------------------|----------|--------------------|----------|--------------------|----------|--------------------|----------|--------------------|----------|--------------------|----------|--------------------|----------|
| Irrigated once a week after heading. Received 35 inches of water, except plat 17 which had 37 inches.       |          |                    |          |                    |          |                    |          |                    |          |                    |          |                    |          |
|                                                                                                             |          | Plat 2             |          | Plat 6             |          | Plat 9             |          | Plat 12            |          | Plat 13            |          | Plat 17            |          |
| 1st ft.                                                                                                     | SCCH     | 11.2               | C        | 11.7               | C        | 13.3               | C        | 11.6               | C        | 11.6               | Ch       | 11.6               | 11.9     |
| 2nd ft.                                                                                                     | SCC      | 2.6                | C        | 3.5                | C        | 5.7                | SCC      | 5.1                | C        | 5.1                | Ch       | 4.2                | 4.4      |
| 3rd ft.                                                                                                     | SC       | -2.4               | SCh      | 0.3                | SCC      | 0.0                | SC       | 1.4                | SC       | 1.4                | SCC      | -1.2               | -0.1     |
| 4th ft.                                                                                                     | SC+S     | -1.0               | SC       | 1.9                | SCC      | -3.4               | SC+S     | 2.4                | SC       | 2.4                | SC       | -0.1               | 0.6      |
| 5th ft.                                                                                                     | S        | 1.7                | S        | -0.6               | SCC+S    | -0.3               | S        | 0.7                | S        | 0.7                | SC+S     | 0.7                | 0.7      |
| 6th ft.                                                                                                     | S        | 0.2                | S        | -0.1               | S        | -0.6               | S        | 0.4                | S        | 0.4                | S        | 1.6                | 0.4      |
| Average                                                                                                     |          | 2.0                |          | 2.7                |          | 2.5                |          | 4.1                |          | 3.6                |          | 2.8                | 3.0      |
| Irrigated once in two weeks after heading. Received 29 inches of water, except plat 11 which had 30 inches. |          |                    |          |                    |          |                    |          |                    |          |                    |          |                    |          |
|                                                                                                             |          | Plat 4             |          | Plat 7             |          | Plat 11            |          | Plat 15            |          | Plat 16            |          | Plat 19            |          |
| 1st ft.                                                                                                     | C        | 13.7               | C        | 10.2               | SCCh     | 10.7               | C        | 13.5               | C        | 12.1               | Ch       | 12.0               | 12.1     |
| 2nd ft.                                                                                                     | Ch       | 4.8                | SCC      | 5.9                | SCC      | 6.3                | C        | 4.2                | C        | 4.1                | Ch       | 2.6                | 4.7      |
| 3rd ft.                                                                                                     | SCC      | 2.7                | SC       | 3.4                | SC       | 3.1                | SCC+SC   | 3.7                | SC       | 2.8                | C        | -0.5               | 2.5      |
| 4th ft.                                                                                                     | SCC+SSC  | -0.4               | SC       | -1.8               | SC       | 4.6                | SCh      | 2.7                | SC       | 3.1                | SCC      | 1.5                | 2.0      |
| 5th ft.                                                                                                     | SSC      | -1.1               | S        | -0.5               | S        | 1.1                | SC+S     | 0.6                | SC+S     | 1.7                | S        | -0.3               | 0.7      |
| 6th ft.                                                                                                     | S        | 1.1                | S        | -0.3               | S        | 1.1                | S        | 0.0                | S        | 0.8                | S        | -0.1               | 0.4      |
| Average                                                                                                     |          | 3.5                |          | 2.8                |          | 5.0                |          | 4.1                |          | 4.1                |          | 2.5                | 3.7      |
| Irrigated once in three weeks after heading. Received 24 inches of water.                                   |          |                    |          |                    |          |                    |          |                    |          |                    |          |                    |          |
|                                                                                                             |          | Plat 3             |          | Plat 5             |          | Plat 10            |          | Plat 14            |          | Plat 18            |          | Plat 20            |          |
| 1st ft.                                                                                                     | C        | 13.2               | C        | 14.7               | C        | 14.1               | C        | 17.7               | Ch       | 14.9               | Ch       | 15.9               | 15.1     |
| 2nd ft.                                                                                                     | C        | 3.0                | C        | 5.8                | C        | 6.0                | C        | 6.7                | Ch       | 8.9                | SCh      | 7.9                | 6.4      |
| 3rd ft.                                                                                                     | SC       | 6.7                | SC       | 2.8                | SCh      | 3.2                | SC h     | 2.3                | C        | 3.4                | SC       | -0.6               | 3.0      |
| 4th ft.                                                                                                     | SC       | 5.1                | SC       | 1.7                | SSC      | 2.5                | SC+S     | 1.6                | SCC      | 0.0                | SC+S     | 2.8                | 2.3      |
| 5th ft.                                                                                                     | SSC      | 2.1                | S        | 4.2                | S        | 0.9                | S        | 0.6                | S        | -0.8               | S        | 0.3                | 1.2      |
| 6th ft.                                                                                                     | S        | 1.2                | S        | 1.2                | S        | 0.9                | S        | 0.7                | S        | -0.1               | S        | -0.7               | 0.5      |
| Average                                                                                                     |          | 5.2                |          | 5.1                |          | 4.6                |          | 4.9                |          | 4.4                |          | 4.3                | 4.7      |

**Table 7.—Average Gain or Loss in Moisture During the Season—Continued.**

| Depth   | Texture. | Not Irrigated after heading. Received 18 inches of water |          |                    |          |                    |          |                    |          |                    |          |
|---------|----------|----------------------------------------------------------|----------|--------------------|----------|--------------------|----------|--------------------|----------|--------------------|----------|
|         |          | Moisture per cent.                                       | Texture. | Moisture per cent. | Texture. | Moisture per cent. | Texture. | Moisture per cent. | Texture. | Moisture per cent. | Average. |
|         |          | Plat 1      Plat 8                                       |          |                    |          |                    |          |                    |          |                    |          |
| 1st ft. | SCCh     | 17.1                                                     | SCCh     | 17.6               |          |                    |          |                    |          |                    | 17.4     |
| 2nd ft. | SCCh     | 6.4                                                      | SCCh     | 6.1                |          |                    |          |                    |          |                    | 6.3      |
| 3rd ft. | SC       | 4.8                                                      | SC       | 0.7                |          |                    |          |                    |          |                    | 2.6      |
| 4th ft. | S        | 1.7                                                      | SC+s     | 0.5                |          |                    |          |                    |          |                    | 1.1      |
| 5th ft. | S        | 2.3                                                      | S        | 2.5                |          |                    |          |                    |          |                    | 2.4      |
| 6th ft. | S        | 0.6                                                      | S        | 2.5                |          |                    |          |                    |          |                    | 1.6      |
| Average |          | 5.4                                                      |          | 5.0                |          |                    |          |                    |          |                    | 5.2      |

From this table it will be seen that the texture is very unfavorable to the economical use of water because of the favorable conditions for the rapid loss of water by evaporation. The texture of the first and second feet is clay loam to clay and this prevents the water from percolating quickly to the lower layers. The water being held close to the surface for a considerable length of time is exposed to more favorable conditions for evaporation and the loss is probably much greater than it would be if the water penetrated more deeply into the soil and was brought back to the surface by capillarity. This retention of the water near the surface was very marked after the first irrigation, in January, at which time the surface soil was very loose from the recent cultivation. The upper half of the first foot of the soil was then saturated and very miry while the lower half was quite stiff. Plats 19 and 20 have the heaviest and most impervious surface foot; although plats 17 and 18 are nearly as heavy, and at the time of the first irrigation the water was held so completely in the plowed portion of the first foot that four days after irrigation when a hole was bored, the water drained out of this surface portion into the hole. It was seven days before enough of the water had soaked in, or evaporated from the surface, to permit of

samples being taken without this drainage. The lowest spots on these plats, which therefore received the most water, required two or three days for the standing water to disappear from the surface.

The plats on which the first two feet is clay loam allowed the water to percolate more rapidly and on some of these the standing water had disappeared within twelve hours. This was a six inch irrigation. Later in the season when the soil had settled and cracked, the water penetrated the heavier soils rather more rapidly.

**TEXTURE.**—On comparing the textures of the first two feet of the four series of plats, it is found that while the textures on the different plats vary, the averages for the first three series are fairly similar; series three has slightly the heavier, while series four is lighter than the others.

The textures of the third, fourth, and fifth feet are quite variable, so much so, that it is difficult to compare them. The sixth foot is in all cases sand.

**MOISTURE.**—The total average gain in moisture for each series increases from 3.0 per cent. in series one which received the most frequent irrigations and greatest amount of water, to 5.2 per cent. in series four which received the fewest number of irrigations and least water.

An increasing gain, such as is found in the averages of the first foot for each series, would be expected, and such gain might be expected in the second, and, possibly, in the third foot because these gains would be due to the fact that, in the series which received the fewest number of irrigations, the soil would lose the greatest amount of moisture between the irrigations and therefore the differences between the amounts of moisture present after irrigation and those present before would be greatest; but it is scarcely to be expected that these changes would affect the fourth to sixth feet to the extent shown by these figures. It would be expected that the fourth to sixth feet would show an increase in moisture on the plats that received the greatest amount of water, provided that they received more water than was necessary to supply the loss from evaporation and the water used by the plants, after the first three feet had had their moisture content raised to the point where they would admit of some of their water passing down by capillarity at least if not by percolation. The increase in moisture content at these depths on the plats of series one is not as much as



would be expected from capillary movement and shows practically no signs of percolation.

The results shown by the figures lead to the conclusion that below the second foot there was little gain in moisture in any of the series of plats. The most of the gains shown are within the limits of error of sampling, i. e. the amounts shown are not greater than the difference in moisture content between two samples taken at the same depth from places a few feet apart on the same plat.

An examination of the detailed data for each plat shows that, after making allowances for the prominent variations between samples taken before and after the same irrigation, there was no marked increase of moisture below the third foot; and, further, that even the series of plats that received 35 inches of water contained on the whole rather less moisture at the close of the season than they did after the first irrigation.

The results show conclusively that none of the water applied to the plats reached the water table which lies at about 14 feet from the surface of the land; or in other words, that there was practically no loss from seepage and that probably very little of the water passed below the limits of the roots of the wheat.



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**TUBERCULOSIS IN CATTLE**

**AND**  
**Tuberculin Tests of the Station Herd.**

**BY**  
**JOHN M. SCOTT.**

**SANTA FE, N. M.:**  
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# NEW MEXICO AGRICULTURAL EXPERIMENT STATION

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## **SUMMARY**

1. Bovine tuberculosis is known to be infectious, and it is general throughout the United States.

2. The agents for carrying and spreading tubercular germs are many; such as food, feed racks, salt boxes, watering tanks, etc.

3. Since a physical examination is not sufficient to diagnose a case as tubercular, some other test must be used, and the tuberculin test has proven to be the most reliable, but great care is necessary in making the test.

4. Some experiments show that the use of milk from tubercular cows, whether the udder be affected or not, will cause tuberculosis.

5. The following preventative measures may be taken to assist in retarding the progress of the disease and which will tend to eradicate it after having secured a foothold: All breeding animals brought into the Territory should be subjected to the tuberculin test, all suspected herds should be tested at least once a year, and all reacting animals should be slaughtered and the carcass either buried or burned.

6. All reacting animals in the Station herd, 15.8 per cent, upon post-mortem examination were found to be tubercular.

7. The tests made, on the Station herd, show that tuberculosis exists in New Mexico.

## **INTRODUCTION**

At the present time authorities still differ as to whether human and bovine tuberculosis are caused by the same bacilli or by entirely different bacilli, but the weight of opinion is that bovine tuberculosis can and is transmitted to children by the use of milk from tubercular animals; therefore, it is, perhaps, much safer for the consumer to take the necessary precautions against infection until authorities come to an agreement on the subject.

It is not the purpose of the writer to enter into a discussion

of this much-debated question. Until authorities agree upon the subject, it is much safer to consider that Human and Bovine tuberculosis are caused by the same germ, and that the disease is transmissible from one to the other, and for the purpose of this bulletin they are so considered.

### TUBERCULOSIS

We may define tuberculosis as a communicable disease due to the presence of microscopical plant parasites in the animal body. These parasites, or germs as they are called, cause the formation of hard, knotty bunches called tubercles, which vary in size from that of a pin head to that of a walnut, and often larger. When these tubercles are cut open with a knife a gritty feeling or sensation is produced very much the same as when a knife is cutting through sand. This is one of the best ways, in the post-mortem, to diagnose the disease as tuberculosis.

Tuberculosis is known by a variety of names. It is called "lupus" if confined to the skin only; by the Greeks it is called "phthisis," meaning in their language "wasting" or "consumption."

Perhaps there is no disease which has been more thoroughly discussed during the past ten years than tuberculosis; discussed from all points of view, through the agency of the press and from the platform. But notwithstanding all that has been written and said on the subject, still many people are very indifferent and negligent in their efforts to retard or eradicate this dreadful malady. Two principal reasons may be given for taking vigorous steps to eradicate the disease. First, that of public health; and second, that of successful animal industry.

Since it is believed by some authorities that tuberculosis is communicable from man to animals, the question of "public health" is of grave importance, especially so in the arid regions of the Southwest, comprising Colorado, Arizona, New Mexico, and part of Texas, because these regions are becoming the "dumping ground" for a large per cent of the tubercular

patients of the Northern and Eastern states. The arid regions of the Southwest furnish a large per cent of the cattle that are each year placed in the feed lots in the corn belts of the central states, hence it is evident that, if these states are to furnish in the future the cattle for the Eastern markets, some measures should be taken to eradicate the disease from our Territory. The climatic conditions of the Southwest are excellent to hold the disease in check, but that is not sufficient as something should be done to exterminate the disease after it has secured a foothold.

### SYMPTOMS

It is unfortunate that this disease invades the animal system through so many different avenues, and in most cases has reached a critical stage before any external signs are apparent by which it can be diagnosed, though clinical symptoms cannot be accepted without further proof of the disease. Still, it makes considerable difference which avenue of infection the germs take to produce external symptoms by which it can be diagnosed. It is frequently the case, when infection takes place through the food that the disease makes its first appearance by an acute attack of diarrhea, and when treatment is given for such, the patient seems much improved, when, to our surprise, some unknown cause brings on a second attack, which, in most cases, is likely to be more acute than the first. The patient may continue in this manner for an indefinite length of time, when the characteristic "consumption" begins and the animal finally dies, an emaciated looking object. The progress of the disease is not always so rapid, as the writer has seen animals that were known to have tuberculosis for more than a year and, from all external appearances, were in perfect health. Undoubtedly, such animals are more dangerous to a herd than one in which the external appearance would indicate a disease of this nature. Generally if an animal in the herd is not doing well and becomes emaciated, it is taken from the herd and given extra care until there are signs of improvement. In this way the

healthy animals do not come in contact with those that are in any way diseased.

Infection through the organs of respiration is very likely to occur where the animals are closely confined in sheds or stables, where the stalls have been bespattered with the discharges from diseased animals, and allowed to dry; and by sweeping, the dust in the stable is laden with the disease-producing germs. The symptoms of the disease are quite different from those when the germs enter through the food. When the germs enter the air tubes and find convenient lodgement, they form a colony which will grow and in turn spread to all parts of the organs of respiration forming new colonies. This method of growth continues until there is enough foreign matter in the lungs and air passages to cause an irritation, when the animal begins to cough. When this stage is reached, the animal begins to lose flesh, and it makes little difference as to the kind of food given, since genuine consumption has started which, in a short time, ends in the death of the animal.

Since any and all organs of the body are liable to be affected with this malady, the symptoms, therefore, vary more or less, according to the organ affected. If, for instance, the brain be affected, the disease will manifest itself in a variety of nervous symptoms according to the part of the organ affected; that is, the sense of smell, sight, or hearing may be impaired.

To mention all of the many symptoms of tuberculosis, would require more space than this bulletin will afford, but it seems fitting to give a brief description as to how it affects the mammary glands of the cow. When this organ contains tubercular germs, there may or may not be acute inflammation, but as the disease advances, tumors will be formed which will furnish millions of the disease-producing germs.

However, it is unfortunate, that, from any external examination, one is unable to diagnose the case as being caused by the bacilli of tuberculosis or by some other less harmful germ. Since authorities differ on these points, without a



microscopical examination, the milk from cows with diseased udders, whether tubercular or not, should first be pasteurized to prevent further spread of the germs.

### HOW INFECTION MAY OCCUR

That bovine tuberculosis is an infectious disease is no longer a disputed question, and ways of carrying and spreading the tubercular germs are many. Perhaps the most common vehicle for disseminating the disease is the manner of feeding. The herd, as a rule, is all fed from the same racks and boxes, thus the food, racks, and boxes come in contact with the tubercular animals, and, therefore, they become contaminated with the bacilli. The next animal that comes along partakes of the contaminated food and, as a result, also becomes tubercular. The same may be said of the watering tanks, salt boxes, etc.

Another avenue of infection, especially in young animals, is the milk. At the present time authorities differ, some claiming that the milk of tubercular cows carries the bacilli, while others maintain that the milk does not contain the germs unless the udder be affected; therefore, since authorities differ, it may possibly be safer if the milk of tubercular cows be used at all, that it should first be Pasteurized. Another very common means of spreading the disease, is through the purchase of breeding animals. This means should, perhaps, receive the most attention from the stockmen of this Territory, as each year large numbers of breeding animals are brought in from the neighboring states and placed upon our ranges. Just as long as the buyers make no objection, just so long will the breeders continue, knowingly or unknowingly, to sell infected animals.

### EXTENT OF TUBERCULOSIS

Tuberculosis is not confined to any one section or state, but it is found in every state in the Union and every country on the globe. Nor are its ravages confined only to cattle. Very few, if any, of our domesticated animals, are exempt from its

attacks; all races of men also are subject to the dreaded disease.

We find from statistics, that among human beings one-seventh of all deaths recorded are due to tuberculosis. This, however, does not include a large per cent of cases of the disease that are cut short by death from other causes.

The following, taken from Bulletin No. 84, of the Wisconsin Experiment Station, will give an idea of the extent of the disease in the United States. "These statistics probably represent more than the actual average of the disease, because in many cases the test has been applied to suspected herds only, and not universally to all cattle in a region."

"New England States.—In Vermont, a large number of tests have been made. Since February, 1895, the State Board of Agriculture has tested 60,000 head, and of these 2,390 or 3.9 per cent. were found to be tubercular.

Several methods of determining the amount of the disease in herds, have been tried in Massachusetts. For a number of years, it has been customary to make a physical inspection of all herds and quarantine all animals suspected of the disease. Of these, 24,685 were tested with tuberculin, from 1894 to 1897, with the result that 12,443, or practically one-half, were adjudged tubercular. In about one-fifth of these, the disease was found to be generalized. From June to December, 1895, tests of entire herds were made upon application of owners, and 4,093 examinations showed 1,080 reactions, or 26.4 per cent. of stock affected.

Of 6,300 cattle tested in Connecticut, 14.2 per cent. reacted.

Middle States.—In 1894, the Tuberculosis Committee of the New York State Board of Health confined part of its work to a given area that was thought to be comparatively free from general infection from other sources, 947 animals were tested, 66 of which were condemned, or 6.9 per cent.

In 1897-8, 1,200 animals were tested. 163 were found to be tubercular, or 18.4 per cent\*\*\*.

North Central States.—During two years prior to November, 1898, 929 dairy cattle were tested by the Illinois State Board

of Live Stock Commissioners, 12 per cent. of which reacted. From May to November, 1899, 3,655 animals were tested, 560 of which reacted, or 15.32 per cent.

In Michigan, about 13 per cent. of the cattle tested by the State Veterinarian have been found to be tubercular\*\*\*."

### TUBERCULIN

\* "Tuberculin is a product (an excretion, so to speak) of the tubercle bacillus (the cause of tuberculosis); it is present in the bodies of all tuberculosis patients.

It was prepared artificially, by Dr. Robert Koch, by growing the tubercle bacillus in a nutriment medium, and separating the tuberculin resulting from this process of growth by means of heat to kill the germs and filtering processes to remove the dead organisms."

Tuberculin was first prepared, not as a diagnostic, but as a curative agent in human beings, but experiments showed that for this purpose, it was a failure. However, in cattle, it has proven to be the best diagnostic agent, with the exception of the post-mortem, which is really the only infallible test, but too expensive, to say the least. The use of the tuberculin test, which is based on the conditions that, when a given amount of the solution is injected into the animal which is affected with tuberculosis, except where the disease has reached an advanced stage, produces a temporary fever; that is, the temperature of the animal's body, which is normally about 102° F., varying with conditions, will, in from 8 to 18 hours after the injection of tuberculin, show a rise of two or more degrees F. above the normal temperature. If there be only a rise of 1.5° F., the animal should be considered suspicious and should be isolated and tested again in about six weeks or two months. This rise in temperature is what is known as the reaction and should continue for from 6 to 10 hours or more. Under normal conditions, all animals that react will be found to be tubercular. In rare instances do healthy animals react. As a rule, if a tubercular animal fails to react, it is because the

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\* Bulletin No. 79, Kansas Agricultural Experiment Station.

disease has reached such a critical stage that it can usually be detected by a physical examination.

### HOW TO APPLY THE TUBERCULIN

The general principle underlying all methods, is to obtain the normal temperature of all animals to be tested. This is accomplished by inserting a fever thermometer into the rectum and allowing it to remain for at least two minutes. The temperatures are taken every two hours, beginning at 8 a. m. and continuing until 10 p. m. of the same day, at which time the injection of the tuberculin is made. This is accomplished by the use of a hypodermic syringe. The temperatures are not taken again until 8 a. m., the following day (ten hours after injection) and then are continued every two hours as on the previous day, until 6 p. m., or later if there be any evidence of a rise in temperature.

### HOW MUCH TUBERCULIN TO INJECT

The amount of tuberculin injected is commonly given by authorities as 2 c. c. per thousand pounds live weight.

Some authorities suggest that if the animal be suspected of having tuberculosis in an advanced stage, the amount should be increased somewhat, perhaps to 2.5 c. c. per thousand pounds live weight.

### WHERE TO INJECT THE TUBERCULIN

It makes little difference where the tuberculin is injected, but experience has taught that the neck or shoulder is the most convenient place to work. It is much easier to hold this part quiet than any other portion of the body.

### EXPERIMENTS IN FEEDING THE MILK OF TUBERCULOSIS COWS

\*"The use of milk on experiment animals for the purpose of artificially inducing the disease in otherwise healthy individuals is a practical way of putting to the test, some of the theories as to sources of danger. If the milk from tuberculous cows, either taken in the ordinary way, or injected

directly into the circulation can induce tuberculosis, the fact becomes one of no ordinary moment. The significance of the experiment has a two-fold importance.

First:—It enables us to account for many cases of the disease in young cattle. It has been shown by repeated observations that the congenital infection is rare. However, calves but a few months old are frequently found to be infected.

Second:—If milk from tuberculous cows possesses infectious properties, the health and safety of the human family becomes the important part of the question. If feeding the milk to lower animals under ordinary conditions will induce the disease, there is no avoiding the conclusion that it can be induced in the human family under the same conditions. This experiment has been repeated with sufficient frequency, and under conditions to prove the certainty of results beyond question. If milk is contaminated with the bacilli of tuberculosis, it will convey the disease. But under what conditions will the milk be so contaminated, is a question for separate solution. It has been vehemently claimed that only milk from cows with udders in which the disease was localized, was to be regarded as in any sense dangerous.

An exhaustive series of experiments was undertaken by the Trustees of the Massachusetts Society for the Promotion of Agriculture, with a view of gaining light on the question. One of the experiments consisted in feeding twenty-one healthy calves on milk from tuberculous cows. At the conclusion of their experiment they report, 'Of these twenty-one animals, eight, or over thirty-three per cent were shown to be tuberculous. That the cows from which the milk for these feeding experiments was derived were free from tuberculosis of the udder, is shown by the following table (table omitted) of their history, and the results of the post-mortem examination.' They draw the following conclusions:

'The possibility of milk from tuberculous udders containing the infectious elements, is undeniable.'

'With the evidence here presented, it is equally undeniable

that milk from diseased cows with no appreciable lesion of the udder may, and not unfrequently does, contain the bacilli of the disease.'

Dr. McKenzie reports that in cases where there were no lesions of the udder, but where tubercular deposits were found in other parts of the body, the milk in forty per cent of the cases proved to be infectious.

This is in accord with the best evidence on this subject and especially does the extensive scientific work of Bang of Copenhagen coincide with these results.

Our Station made experiments on three calves from tuberculous mothers. Two were allowed to take the milk from the mothers. These cows were but slightly affected, the udders to all appearances being free from disease, and no bacilli were detected in the milk when examined under the microscope. Both of these calves developed tuberculosis. A third calf from a tuberculous mother was not allowed to take the mother's milk, but was taken as soon as born and kept on the milk of a cow that had been tested and found to be healthy. This calf never showed reactions when tested with tuberculin. It was slaughtered at the age of three months, and thorough examination failed to detect any sign of disease.

This experiment tends to show that calves from tuberculous mothers are not necessarily tuberculous at birth, but that infection will take place when the udders are healthy and when there is no external evidence of disease."

#### **SOME PRECAUTIONS THAT MAY BE TAKEN**

To say what should be done to assist in preventing the spread of tuberculosis in this Territory is an easy matter, but the all important question is, are the ranchmen ready to work for legislative measures that will not only retard the spread of the disease but that will in time eradicate the disease from the Territory?

The old saying, "Prevention is better than a cure," is a true

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\* Bulletin No 29, Iowa Experiment Station.

with tuberculosis as any other disease. Therefore, why should not preventative rather than curative measures be taken? Other states have done so. Why should not New Mexico pass laws requiring that all cattle for breeding purposes, before they enter the Territory, be subjected to the tuberculin test? In this way all breeding stock brought into the Territory in the future would be free from the disease.

If all the cattle in the Territory, especially the breeding stock, be subjected to the tuberculin test each year, and all reacting animals disposed of, it would only be a short time until the cattle of the Territory would be practically free from the disease. This may seem like a costly method, especially so if 10 per cent of a herd should react, but it would be much cheaper to eradicate the disease now than five or ten years hence when 50 per cent of the herd may be tubercular.

As to the extent of tuberculosis in this Territory we are unable to give any definite information, as we have no data regarding tests that may have been made, except the tests made with the Station herd. Since two of the cows in the Station herd that reacted were cows bred and raised in this Territory, it is reasonable to suspect that many others are similarly affected. In the Station herd there were practically 15.8 per cent found to be tubercular. If this represents an average of the Territory, it is gratifying to think that the per cent of deceased stock in this Territory is so low.

### TESTS OF THE STATION HERD

The Station herd of cows, consisting of 19 head, were tested November 13th and 14th, 1903, for tuberculosis, with the tuberculin test. The tuberculin for the test was obtained from the Bureau of Animal Husbandry, Washington, D. C. The tuberculin was injected at the rate of 2 c. c. per 1,000 pounds live weight. Part of the herd were again tested December 13th and 14th, 1904.

In both of these tests all precautions possible were taken to avoid any unnatural conditions that might have any effect on the temperature of the animals.

Table I, shows temperature readings for November 13th and 14th, 1903, before and after injection, also the amount of tuberculin injected, the weight, breed, age, and sex and the rise in temperature of each animal.

Table II, shows temperature readings before and after injection for the test made December 13th and 14th, 1904.

From Table I, it will be seen that cows numbers 1, 4, and 29 reacted, showing a difference in temperature, between the maximum before and after injection; for No. 1, of 3.7°, No. 4, of 3.2°, and No. 29, of 1.5° F.

From all external appearance, (see plates Nos. 1 and 3) cows Nos. 1 and 4, showed no external signs of being tubercular, except the coat of cow No. 1 was a little rough,—both animals being fat and of a healthy appearance. The cow No. 29, although only showing a rise in temperature of 1.5° F., yet from all external appearance, (see plate No. 2) one would diagnose her case as in an advanced stage of tuberculosis, as she had a bad cough and was also a badly emaciated looking object. Upon post-mortem examination of cow No. 29 the liver was affected and the lungs, bronchial glands, and pleura were a complete mass of tubercles. (See plate No. 5).

In cow No. 1, upon post-mortem, the disease was found to be local, the lungs only being slightly affected.

Cow No. 4, was not slaughtered at this time, as she was very fat and also heavy in calf, and it was thought that her condition might have something to do with her rise in temperature. But she was isolated and again tested, December 13th and 14th, 1904, when she again reacted and upon post-mortem her lungs were found to be slightly affected. It may be of interest to note that the calf (see plate No. 3) this cow raised, while she was isolated, when tested showed no signs of being tubercular.



**ACKNOWLEDGMENTS**

The writer is much indebted to Professor J. J. Vernon, of this Station for valuable assistance in making the tests and also in the preparation of this bulletin; and to the Bureau of Animal Husbandry, U. S. Department of Agriculture, Washington, D. C., for the tuberculin used in the test made November 13th and 14th, 1903.

Credit is given in the body of this bulletin for material taken from other publications.

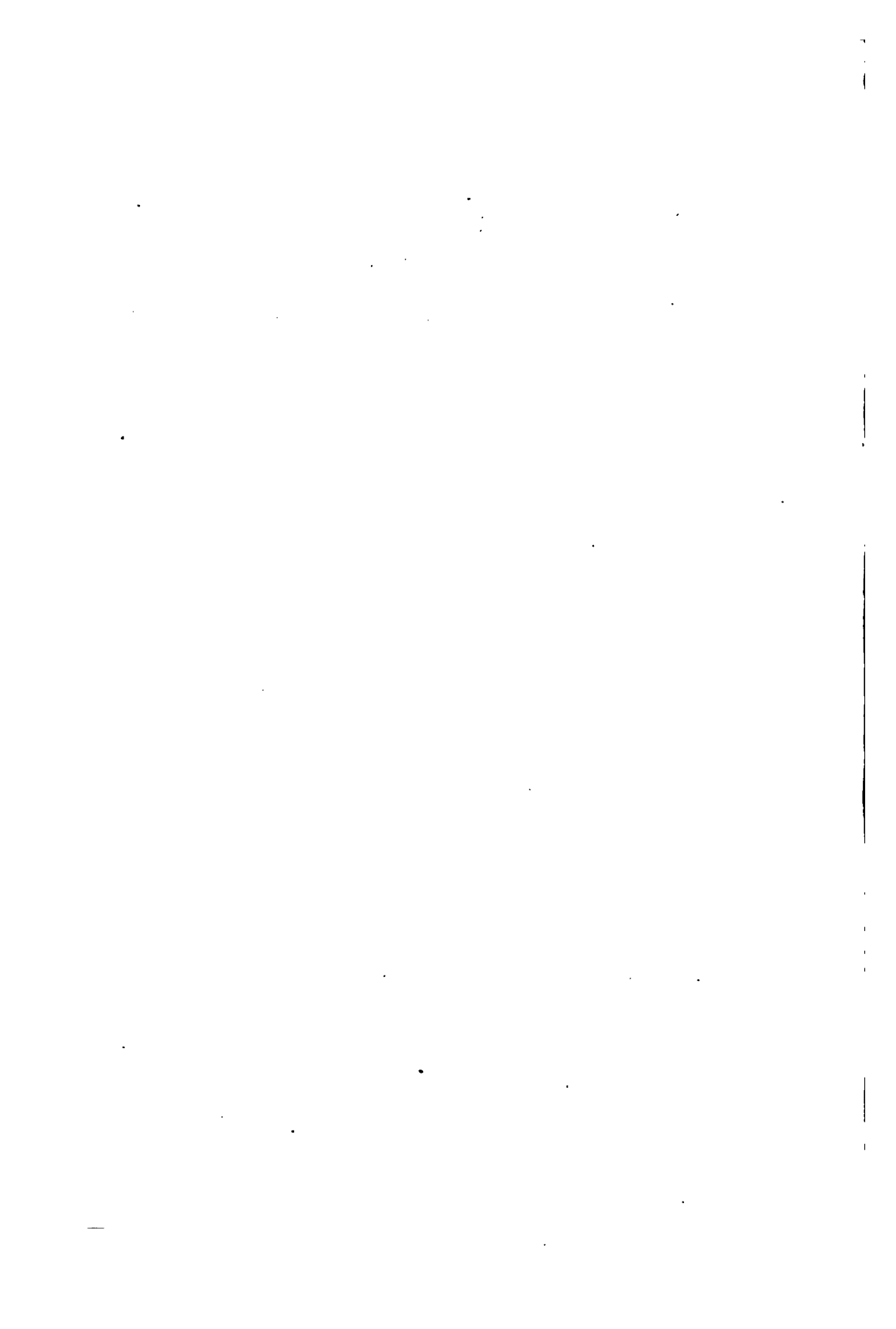




TABLE 1.—TEMPERATURE RECORD

| Record Number | BREED.              | Sex. | Age of Animals Years | Weight of Animals Lbs. | Amount of Tuberculin Injected C. C. | Before Injection. |          |       |         |         |    |
|---------------|---------------------|------|----------------------|------------------------|-------------------------------------|-------------------|----------|-------|---------|---------|----|
|               |                     |      |                      |                        |                                     | A. M. 8           | A. M. 10 | M. 12 | P. M. 2 | P. M. 4 | P. |
| 1             | Grade Short Horn... | F    | 11.0                 | 1250                   | 2.5                                 | 100.6             | 100.4    | 101.1 | 101.5   | 102.7   | 1  |
| 4             | Short Horn.....     | F    | 5.75                 | 1780                   | 3.0                                 | 102.0             | 102.1    | 102.6 | 103.5   | 103.0   | 1  |
| 5             | Hereford.....       | F    | 5.0                  | 1284                   | 2.5                                 | 101.6             | 101.4    | 101.5 | 101.2   | 101.8   | 1  |
| 6             | Grade Short Horn... | F    | 3.5                  | 1090                   | 2.0                                 | 101.1             | 101.6    | 101.1 | 100.9   | 101.7   | 1  |
| 7             | Grade Jersey.....   | F    | 3.0                  | 1046                   | 2.0                                 | 101.6             | 101.0    | 100.8 | 101.2   | 101.5   | 1  |
| 8             | Grade Short Horn... | F    | 1.75                 | 984                    | 1.5                                 | 102.4             | 101.6    | 101.1 | 102.7   | 103.0   | 1  |
| 9             | Grade Jersey.....   | F    | U                    | 1148                   | 2.25                                | 102.2             | 101.4    | 101.4 | 102.1   | 102.0   | 1  |
| 10            | Jersey.....         | F    | 2.5                  | 690                    | 1.5                                 | 101.6             | 101.8    | 101.5 | 102.3   | 102.0   | 1  |
| 11            | Grade Guernsey....  | F    | U                    | 1074                   | 2.0                                 | 101.2             | 101.4    | 101.3 | 101.5   | 101.5   | 1  |
| 12            | Grade Jersey.....   | F    | 1.0                  | 744                    | 1.5                                 | 101.6             | 101.5    | 101.9 | 102.3   | 102.1   | 1  |
| 13            | Grade Hereford....  | F    | 1.5                  | 690                    | 1.5                                 | 101.4             | 101.0    | 100.7 | 101.6   | 101.4   | 1  |
| 15            | Grade Short Horn... | F    | 1.3                  | 674                    | 1.0                                 | 101.2             | 101.6    | 101.6 | 101.2   | 101.8   | 1  |
| 19            | Grade Jersey.....   | F    | U                    | 1052                   | 2.0                                 | 102.0             | 102.0    | 102.5 | 102.2   | 102.6   | 1  |
| 20            | Grade Jersey.....   | F    | U                    | 834                    | 2.0                                 | 101.0             | 101.0    | 101.2 | 101.3   | 101.8   | 1  |
| 21            | Grade Jersey.....   | F    | U                    | 1092                   | 2.5                                 | 102.0             | 102.0    | 101.8 | 101.4   | 101.8   | 1  |
| 22            | Grade Jersey.....   | F    | U                    | 910                    | 2.0                                 | 102.0             | 101.4    | 101.3 | 101.2   | 101.8   | 1  |
| 29            | Grade Short Horn... | F    | U                    | 900                    | 2.0                                 | 99.3              | 100.6    | 102.4 | 101.6   | 104.9   | 1  |
| 0             | Jersey.....         | F    | 5.0                  | 1100                   | 2.0                                 | 100.8             | 100.4    | 101.7 | 102.0   | 102.1   | 1  |
| 68155         | Jersey.....         | M    | 1.25                 | 625                    | 1.5                                 | 102.4             | 102.2    | 101.6 | 101.3   | 102.0   | 1  |

Note.—F=Female  
M=Male  
U=Unknown

TABLE 2.—TEMPERATURE RECORD

| Record Number | BREED.            | Sex. | Age of Animals Years | Weight of Animals Lbs. | Amount of Tuberculin Injected C. C. | Before Injection. |          |       |         |         |    |
|---------------|-------------------|------|----------------------|------------------------|-------------------------------------|-------------------|----------|-------|---------|---------|----|
|               |                   |      |                      |                        |                                     | A. M. 8           | A. M. 10 | M. 12 | P. M. 2 | P. M. 4 | P. |
| 4             | Short Horn.....   | F    | 6.75                 | .....                  | 3.0                                 | 100.6             | 100.9    | 101.3 | 101.4   | 102.7   | 1  |
| 17            | Grade Jersey..... | F    | 1.3                  | .....                  | 2.25                                | 100.1             | 101.3    | 102.1 | 102.3   | 102.5   | 1  |
| 23            | Jersey.....       | F    | .75                  | .....                  | 1.5                                 | 101.2             | 102.4    | 102.3 | 101.8   | 103.1   | 1  |
| 24            | Short Horn.....   | F    | .75                  | .....                  | 1.75                                | 101.4             | 102.5    | 102.4 | 102.1   | 102.2   | 1  |
| 28            | Grade Jersey..... | F    | U                    | .....                  | 2.25                                | 101.1             | 101.2    | 102.2 | 102.4   | 103.2   | 1  |
| 68155         | Jersey.....       | M    | 2.3                  | .....                  | 2.5                                 | 101.1             | 101.2    | 100.8 | 101.3   | 101.6   | 1  |

Note.—F=Female  
M=Male  
U=Unknown

# DS OF STATION HERD—1903.

| L. |            |             | After Injection. |             |          |            |            |            |            |             | Maximum<br>Before After<br>Difference. |       |     |
|----|------------|-------------|------------------|-------------|----------|------------|------------|------------|------------|-------------|----------------------------------------|-------|-----|
|    | P. M.<br>8 | P. M.<br>10 | A. M.<br>8       | A. M.<br>10 | M.<br>12 | P. M.<br>2 | P. M.<br>4 | P. M.<br>6 | P. M.<br>8 | P. M.<br>10 |                                        |       |     |
| 9  | 101.3      | 101.2       | 102.7            | 105.4       | 106.4    | 106.0      | 105.6      | 103.2      | 102.2      | 101.6       | 102.7                                  | 106.4 | 3.7 |
| 0  | 102.8      | 102.5       | 105.6            | 107.2       | 106.1    | 106.2      | 105.4      | 105.8      | 104.5      | 103.9       | 104.0                                  | 107.2 | 3.2 |
| 7  | 101.5      | 101.2       | 101.2            | 101.4       | 101.2    | 101.6      | 101.4      | 100.7      | .....      | .....       | 101.8                                  | 101.6 | -.2 |
| 0  | 101.8      | 101.6       | 101.3            | 102.4       | 101.1    | 101.5      | 101.6      | 101.6      | .....      | .....       | 102.0                                  | 102.4 | .4  |
| 2  | 102.0      | 102.1       | 101.5            | 100.9       | 101.2    | 101.3      | 101.4      | 102.4      | .....      | .....       | 102.2                                  | 102.4 | .2  |
| 4  | 103.0      | 102.8       | 102.2            | 101.5       | 102.0    | 101.9      | 102.7      | 103.9      | .....      | .....       | 103.4                                  | 103.9 | .5  |
| 9  | 102.3      | 102.2       | 101.4            | 101.7       | 101.6    | 101.8      | 102.4      | 102.1      | .....      | .....       | 102.9                                  | 102.4 | -.5 |
| 8  | 101.4      | 101.2       | 100.9            | 101.0       | 101.4    | 101.8      | 102.8      | 101.8      | .....      | .....       | 102.3                                  | 102.8 | .5  |
| 9  | 101.7      | 100.0       | 100.8            | 101.0       | 100.6    | 100.9      | 101.2      | 101.7      | .....      | .....       | 101.9                                  | 101.7 | -.2 |
| 5  | 103.0      | 102.4       | 101.7            | 101.7       | 101.9    | 102.4      | 102.4      | 103.2      | .....      | .....       | 103.5                                  | 103.2 | -.3 |
| 5  | 101.9      | 102.0       | 101.5            | 101.4       | 101.1    | 101.5      | 101.2      | 102.8      | .....      | .....       | 102.5                                  | 102.8 | .3  |
| 1  | 102.0      | 102.4       | 101.4            | 101.3       | 101.2    | 101.7      | 102.0      | 102.4      | .....      | .....       | 102.4                                  | 102.4 | .0  |
| 2  | 103.1      | 102.2       | 101.8            | 101.8       | 102.0    | 102.3      | 103.0      | 103.2      | .....      | .....       | 103.2                                  | 103.2 | .0  |
| 8  | 101.9      | 102.0       | 101.0            | 101.9       | 101.1    | 101.7      | 101.4      | 102.2      | .....      | .....       | 102.0                                  | 102.2 | .2  |
| 8  | 102.0      | 101.8       | 101.1            | 101.4       | 101.2    | 101.4      | 102.0      | 102.3      | .....      | .....       | 102.3                                  | 102.3 | -.5 |
| 9  | 101.8      | 101.6       | 101.7            | 101.1       | 100.8    | 101.0      | 101.6      | 102.5      | .....      | .....       | 102.9                                  | 102.5 | -.4 |
| 4  | 101.1      | 101.5       | 101.8            | 103.8       | 106.4    | 106.4      | 105.1      | 102.6      | 100.0      | 99.8        | 104.9                                  | 106.4 | 1.5 |
| 7  | 102.4      | 101.6       | 101.6            | 101.4       | 101.7    | 102.6      | 102.2      | 102.2      | .....      | .....       | 102.4                                  | 102.6 | .2  |
| 1  | 102.1      | 102.4       | 101.9            | 101.0       | 101.4    | 101.3      | 102.4      | 102.7      | .....      | .....       | 103.1                                  | 102.7 | -.4 |

# ORDS OF STATION HERD—1904.

| L. |            |             | After Injection. |             |          |            |            |            |            |             | Maximum<br>Before After<br>Difference. |       |      |
|----|------------|-------------|------------------|-------------|----------|------------|------------|------------|------------|-------------|----------------------------------------|-------|------|
|    | P. M.<br>8 | P. M.<br>10 | A. M.<br>8       | A. M.<br>10 | M.<br>12 | P. M.<br>2 | P. M.<br>4 | P. M.<br>6 | P. M.<br>8 | P. M.<br>10 |                                        |       |      |
| 3  | 101.8      | 102.0       | 103.6            | 104.0       | 106.0    | 105.8      | 105.7      | 105.7      | 104.1      | 103.9       | 102.7                                  | 106.0 | 3.3  |
| 2  | 102.3      | 102.8       | 101.6            | 101.4       | 101.0    | 102.0      | 102.1      | .....      | .....      | .....       | 102.8                                  | 102.1 | -.7  |
| 9  | 102.0      | 101.9       | 101.0            | 102.0       | 101.6    | 101.9      | 101.7      | .....      | .....      | .....       | 103.1                                  | 102.0 | -1.1 |
| 0  | 102.6      | 102.6       | 101.4            | 102.0       | 102.0    | 102.1      | 102.5      | .....      | .....      | .....       | 102.6                                  | 102.5 | -.1  |
| 7  | 101.8      | 102.1       | 102.0            | 100.8       | 101.6    | 102.3      | 102.0      | .....      | .....      | .....       | 103.2                                  | 102.3 | -.9  |
| 8  | 102.6      | 101.4       | 101.2            | 101.8       | 101.1    | 101.9      | 101.5      | .....      | .....      | .....       | 102.6                                  | 101.9 | -.7  |





Plate No. 1—Cow No. 1.

1





Plate No. 2—Side View of Cow No. 29.





Plate No. 3—Cow No. 4 and Cal.





**Plate No. 5—Internal View of Cow No. 29.**



## **BULLETIN NO. 56**

**NOVEMBER 1905**

**New Mexico College of Agriculture and Mechanic Arts**

**AGRICULTURAL EXPERIMENT STATION**

**AGRICULTURAL COLLEGE, N. M.**



## **THE DUTY OF WELL WATER**

**AND**

**The Cost and Profit on Irrigated Crops in the Rio Grande Valley**

**In cooperation with the Office of Experiment Stations, Irrigation and Drainage Investigations (Elwood Mead, Chief), United States Department of Agriculture.**

**BY**

**J. J. VERNON, A. E. LOVETT and J. M. SCOTT.**

**SANTA FE, N. M.:**

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## SUMMARY AND CONCLUSIONS

1. Very large areas of arid and semi-arid lands in New Mexico, which cannot be irrigated by gravity systems because of various physical difficulties, may be reclaimed by means of pumping from the underflow.
2. Some of the more important essentials for successful pumping are:
  - (a) Abundance of good water near the surface of the ground located in good water-bearing strata.
  - (b) A good soil and a good climate.
  - (c) Fair prices and good markets and marketing facilities.
  - (d) Competent management and the application of good business methods.
3. Pumping may be resorted to under the following conditions:
  - (a) Where there are no surface streams from which to draw irrigation waters.
  - (b) Where the surface streams have eroded their channels so deeply that the expense of building and maintaining ditches for the appropriation of the water would be prohibitive.
  - (c) Where the streams from which irrigation waters are drawn flow during only a portion of the growing season.
  - (d) For reaching lands lying slightly above gravity systems, where there are waste or surplus waters.
4. No perceptible difference, due to a difference in the temperature of the water, was noticeable between the crops grown with well and with river water. The well water in New Mexico was 8.4° F. warmer on the average than Utah river water used for irrigation.
5. Of the two series of alfalfa plats that received the same measured quantity of water, the series of plats that received the water in more frequent and smaller irrigations gave slightly the larger yield of hay during the season. The difference, however, was not sufficiently pronounced to warrant the conclusion, without further trial, that like results would always follow such treatment.
6. The largest yield per inch of water was obtained when a depth of 24 inches was applied to wheat and 39 inches to alfalfa, five cuttings of alfalfa being secured during the season.
7. The results of these experiments have shown quite conclusively that the yearly profits may be considerably increased during years of shortage in the water supply by supplementing the river water with well water.

## THE DUTY OF WELL WATER

8. Averaging the results obtained from crops grown with well water during the season of 1904, we have the following:

- (a) Depth of water required: Alfalfa 36.4, wheat 26.6, corn 25.2 and sweet potatoes 17.6 inches.
- (b) Cost of pumping per acre: Alfalfa \$10.50, wheat \$9.80, corn \$6.92, and sweet potatoes \$4.91.
- (c) Cost of applying the water per acre: Alfalfa \$1.23, corn 85 cents, and sweet potatoes 64 cents.
- (d) The yield per acre: Alfalfa 2.33 tons, corn 31.9 bushels, and sweet potatoes 10,000 pounds.
- (e) The value of the crop per acre: Alfalfa \$35.03, wheat \$18.09, corn (including the stover) \$36.27, and sweet potatoes \$170.00.

## INTRODUCTION

Irrigation problems are pre-eminent in the arid west. The wealth and the welfare of a very large portion of the people of this section are dependent almost entirely upon irrigation. Something like 4,000,000 acres have been reclaimed from the barren wastes and transformed by irrigation into fertile agricultural areas. "To reclaim all the land possible will involve the spreading of water over a surface as large as New England, with New York added."\* After all of the available waters of our streams have been appropriated and judiciously applied to crops, there yet remains the underflow, by the appropriation of which millions of acres may be added to the agricultural areas of the country. In 1899 there were 169,644 acres furnished with water from wells.\*\* This fact indicates that the use of well water for irrigation purposes is already of vast importance and that its influence on the future of agriculture is likely to be far reaching. The solution of the many problems connected with irrigation in New Mexico has only been well begun. Enough, however, has been accomplished to indicate that it will prove a most fertile field for research,—one that, because of its bearing upon the economics of agriculture, is destined to prove of most vital interest to the irrigator.

### Essentials for Success

There are a number of conditions which are essential to successful pumping for irrigation. If all the conditions are favorable the cost of pumping will be small, but wherever difficulties are met, the cost of installation and the cost of pumping may be expected to increase in proportion to the seriousness of the obstacles.

The following includes a few of the more important essentials for success in pumping:

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\* Mead, *Irrigation Institutions*, page 11.

\*\* 12th U. S. Census Report, Vol. 6, page 820.

1. Abundance of good water, near the surface of the ground and located in strata of such character that large quantities can be quickly withdrawn.

Good water is water that is not charged with salts to such an extent as to be injurious to the crops to be grown. Many irrigation waters contain a number of the elements that are necessary to plant growth. Potash, soda, phosphoric acid, lime, magnesia, iron, and small amounts of nitrogen are usually found either dissolved or in suspension in the waters of our streams. These elements, if found in too large quantities, are injurious to plant life, and may even poison the plants sufficiently to kill them outright. Sufficiently concentrated they cease to be fertilizing elements, since plants can make use of the food in the soil or in the water only when it forms a very dilute solution.

The waters of our streams often carry great quantities of plant food in solution and in suspension. That which is in solution may be available to the plants as soon as the water is applied to the soil, but it is extremely doubtful if any large quantity of that which is in suspension, in the form of silt and sediment, is at once available. It is very probable that this suspended matter must undergo many changes before it is in a form in which the plant can make use of it.

Because they are clear, well waters do not appear to contain plant food, but this is not necessarily true. In fact, most waters from wells contain more or less of the ingredients necessary to plant growth, and sometimes they contain these fertilizing elements in such concentrated form that they are injurious to plant life. Most of the well waters of this Territory contain considerable quantities of these fertilizing elements; some to an injurious extent.

Good water is very important but the location of this water in a good water-bearing stratum near the surface of the ground is also important. Theoretically, it requires one-half horse power to lift 1,000 gallons of water one foot in one minute; therefore, it will require 10 horse power to lift 1,000 gallons 20 feet in one minute, and 20 horse power to lift the

same quantity 40 feet in one minute. From these figures it will be seen that the nearer the water table is to the surface of the ground the less will be the cost of lifting the water to the surface. The cost increases with each additional foot of lift.

The capacity of the well will be influenced by the kind of strata in which the water is found. Sand forms a very poor water-bearing stratum because the particles lie so closely together that they prevent the rapid movement of the water through the interstices. Furthermore, sand has a tendency to move with the water into the well. Gravel forms one of the best water-bearing strata, due to the fact that the particles lie very loosely upon each other, thus forming large spaces through which the water can pass rapidly into the well to replace that being pumped out. Gravel mixed with sand may be made to form an excellent water-bearing stratum if provision is made for the sand to pass into the well to be pumped out with the water, and at the same time the gravel is withheld. After the sand is removed only the gravel remains surrounding the strainer.

## 2. Good soil and good climatic conditions.

Soils that contain very little plant food will not produce good crops no matter how much water is applied to them unless the elements of plant food are contained in the waters themselves in sufficient quantities for plant growth. It is also true that soils that do contain large amounts of plant food will not grow good crops unless that food is in a condition in which the plants can take it up. Soils that are hard or cloddy do not readily give up the plant food which they contain. The food is locked up, as it were and therefore not readily available to the plant. It is evident that costly water must be put only upon good land. The soil must respond to the influence of the water by giving up its food in quantities sufficient to grow paying crops. If the plant food in the soil is in a form that is soluble in water a portion of this food is dissolved each time an irrigation is given. The plants can then take up the food with the water in which it is held in solu-

tion. It is principally in this way that plants obtain food from the soil. From a statement of these facts it will be seen how important it is that the soil shall not only contain plant food in abundance but that this food shall be in a form in which the plant can use it.

Climate is almost as important a factor as that of soil if paying crops are to be grown. Therefore it becomes one of the factors that will determine whether pumping for irrigation will pay in any given locality. If the seasons are short, if frost occurs early in the fall and late in the spring, and if there are excessively cool nights, etc., heavy yields cannot be expected from most crops.

### 3. Prices, markets, and marketing facilities.

Just as the farmer is guided by prices, markets, and marketing facilities as to what and how much of each crop to plant under the usual methods of irrigation, so must he be guided by these factors when the additional expense of pumping water for irrigation is incurred. Expensive water makes a judicious selection of crops imperative. If the local markets are ample, products of a perishable nature may be grown. If, however, shipment must be made to distant markets, then such crops must be grown, which, when properly prepared, will not only arrive in good condition but will also meet the demands of the market as to quality, size, appearance, etc. The market value of a product can be appreciably enhanced by careful attention to the requirements of the trade and by making a strong appeal to public fancy. Whenever expensive water is used such matters must necessarily claim attention. Costly water has the same effect as high price of land and, therefore, scientific knowledge and business methods must be brought into requisition. Failure must not be assigned to the high price of land nor to expensive water if the failure is really due to the incompetency or slothfulness of the individual.

### 4. The personal factor is by far the most important.

One man would succeed while another would fail under identical conditions. Hardly any two men would arrive at the

same degree of success. The successful man knows the why and the how of agricultural operations in which he is concerned. He will handle his land and his labor properly. He will not only study the market demands and supply them, but will even create new markets for his products. The man who fails seldom understands the importance of detail. He will waste his water, rob his soil, and use neither business methods nor good sense in marketing his products. With his poorly grown and slovenly prepared products he invades the markets and demoralizes them. It makes all the difference between success and failure whether the man understands the principles of agricultural operations or not, and whether he brings to bear upon his work good judgments and business methods—potent factors in any successful undertaking.

#### **Conditions Under Which Pumping May be Employed**

There are four principal conditions under which pumping for irrigation may prove desirable:

1. Where surface streams are lacking from which to irrigate. In the absence of such streams, if other conditions are favorable, irrigation by pumping may be undertaken with the full expectation of making it a success. There are many portions of this Territory where good water may be found in abundance at a distance of from 10 to 30 feet below the surface of the ground. With a lift not to exceed 40 or 50 feet low-lift pumps, which are very economical of power, may be used. A lift of 100 feet need not deter the would-be irrigator, but it must be borne in mind that the cost of pumping increases in proportion to the distance that the water must be lifted. Therefore the net return must be sufficient to cover the additional outlay.

2. Where the surface streams have eroded their channels so deeply below the level of the surrounding country that the expense of taking out ditches through which to lead the water by gravity upon the lands would be too expensive either in construction or in maintenance, or both. Under such a condition the water may be pumped from the streams

directly upon the land. The expense of lifting water from an open stream will usually be much less than when lifting the same amount of water to the same level from a well. In pumping from a stream the head cannot be lowered, for the water is being constantly replaced by the flow from above; on the other hand, even when pumping from the best of wells, the head is usually pulled off several feet, thus increasing the total lift, which in turn increases the cost of pumping.

3. Where the streams that are utilized for irrigation by gravity systems flow only a portion of the cropping season.

Rivers that go dry in summer often have a sandy bed and the water disappears, though it may usually be found near the surface in the dry channel during the remainder of the season. The same water table is usually found under the valley lands adjoining the stream. This underground water is sometimes referred to as the underflow, since it is believed to be the waters of the stream flowing underground. It is quite probable that the term is correctly used, although the movement of the water may be very slow, or even, entirely stopped during a portion of the season, wherever the underlying rock strata outcrop in the bed of the stream. In localities where the surface flow of the streams stops before the crops are made, pumping may be profitably employed to supply one or two irrigations in order to mature the partly-made crop, and, therefore, to greatly increase the yields. The immense returns from one or two irrigations by pumping can readily be appreciated when we bear in mind that a crop is saved, which, but for the timely application of water would have been partly if not totally lost.

4. For reaching lands slightly above gravity systems of irrigation.

In the rice growing sections of the South pumping is resorted to in order to reach lands just above the gravity systems. The pumps, which are placed at intervals along the canals, lift immense quantities of water a few feet to be used upon these lands. By such means the rice growing



areas have been greatly extended. In New Mexico some of our best fruit lands lie just above the valleys proper. With fruit crops on land so well situated as these as to soil and air drainage, it is quite probable that the extra expense incurred in lifting water to them would be more than met by the large returns from the sale of the products.

### THE EXPERIMENTS

The results of the irrigation investigations presented in these pages cover the work of the seasons of 1903 and 1904. Information regarding the following subjects was sought:

1. The duty of well and river water on alfalfa.
2. The cost of growing alfalfa with well and river water.
3. The cost of growing wheat, corn, and sweet potatoes with well water.
4. The determination of the temperature of irrigation water.

### Equipment

The equipment for pumping consists of a 20 H. P. side-crank, slide-valve steam engine, and a 20 H. P. semi-portable steam boiler; a Fairbanks, Morse & Co.'s 6-inch centrifugal pump, which was placed upon the old Station well described in a former bulletin of this Station; and a Byron-Jackson 6-inch centrifugal pump, which was placed upon the new Station well. The engine and boiler mentioned above were used until July 1, 1904, when they were replaced by a modern Erie 30 H. P. center-crank, slide-valve steam engine and a 40 H. P. semi-portable steam boiler.

The equipment for measuring the water consisted of a trapezoidal (Cippoletti) weir, and a hook gauge. The weir was constructed according to specifications given in Part I of Bulletin No. 86, Office of Experiment Stations, United States Department of Agriculture. The cutting edges of the weir were made from 16 gauge galvanized iron. The last 100 feet of the ditch leading to the weir was made as wide as the weir itself. (See *Frontispiece*.) The level of the water below the weir was at all times greater than the specified requirement.

Plate I.



Cippoletti Weir on College Farm. Used in Experiments on Pumping and in Determining Duty of Irrigation Waters

A number of gates were employed in controlling the water where it entered the several plats in the field.

After making a few runs with the pump, it was found that the quantity of water discharged over the weir remained very constant. When using river water, however, it was found necessary not only to provide a spill-gate by means of which an attendant at the hook-gauge could regulate the discharge over the weir, but, owing to the great fluctuation, from time to time, in the head of water in the main canal, which of course caused a like though less marked variation in the flow of the water in the lateral leading to the weir, it was found necessary to provide means for taking care of this surplus water. Two methods were employed: First, when the head-gate in the main canal where the water was withdrawn was near the weir another attendant was placed in charge of the head-gate with instructions to raise or lower it as indicated by the attendant at the weir. Second, when the head-gate was too far away to allow of control in this way a second and much longer spill-gate was placed in the side of the lateral leading to the weir. This spill-gate was made adjustable and was used to carry off the larger portion of the excessive flow,—the attendant at the weir making the final regulation of the discharge over the weir with the small spill-gate.

#### **Labor**

Native Mexican laborers were employed in applying the water to the various crops. The experimental work was in charge of competent assistants, one in the field and one at the pumping plant or measuring weirs.

#### **Fuel**

The coal used for pumping came from two sources. The Gallup coal used during the season of 1903 cost \$6.00 per ton delivered at the pumping plant on the Station farm and the Carthage (San Antonio) coal used during the season of 1904 cost \$5.50 per ton delivered.

### The Duty of Irrigation Water on Alfalfa—1904

The purpose of this experiment was to secure information on two points,—namely, the quantity of water that would produce the largest crops, and whether it is best to apply a given quantity of water in frequent small irrigations or in larger less frequent applications.

|                 |                |  |  |
|-----------------|----------------|--|--|
| <i>Group 1,</i> | <i>Plat 1.</i> |  |  |
| <i>Group 2,</i> | <i>Plat 2.</i> |  |  |
| <i>Group 1,</i> | <i>Plat 3.</i> |  |  |
| <i>Group 2,</i> | <i>Plat 4.</i> |  |  |
| <i>Group 1,</i> | <i>Plat 5.</i> |  |  |
| <i>Group 2,</i> | <i>Plat 6.</i> |  |  |
| <i>Group 1,</i> | <i>Plat 7.</i> |  |  |
| <i>Group 2,</i> | <i>Plat 8.</i> |  |  |

Fig. 1. Plat of Field A.—Vernon, Bulletin 158, Office of Experiment Stations, Irrigation and Drainage Investigations, United States Department of Agriculture.

Two fields that had been in alfalfa for a number of years were selected for this work, two being used because there was no single field on the Station farm of sufficient size to accommodate the experiment.

The soils of this valley have been formed by deposits from the river water, and, therefore, are extremely variable. This variableness in the character of the soil is, perhaps, the most serious difficulty to be met with in securing results that are uniform and representative. For this reason, the fields were divided into plats and the alternate plats grouped together so as to form a unit and receive like treatment.

For convenience the fields were designated by the letters A and B, and the plats which were numbered consecutively from 1 to 16 were thrown into four groups, as will be seen by referring to the diagrams. Field A was divided into eight plats which were numbered consecutively from 1 to 8 and thrown into two groups,—plats 1, 3, 5, and 7 forming group 1 and plats 2, 4, 6, and 8, group 2. Field B likewise was divided into eight plats which were numbered consecutively from 9 to 16 and thrown into two groups,—plats 9, 11, 13,

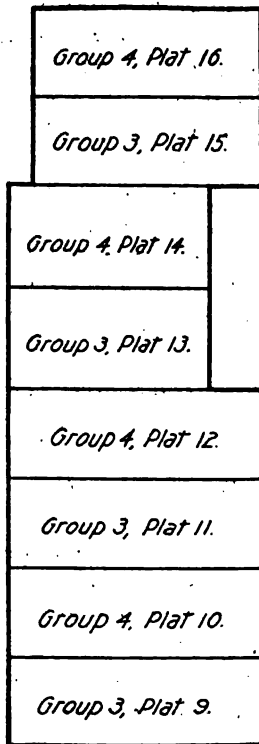


Fig. 2. Plat of Field B.—Vernon, Bulletin 158, Office of Experiment Stations, Irrigation and Drainage Investigations, United States Department of Agriculture.

control the water, a number of cross borders were thrown in. Even after this was done, the water settled to a greater depth on the lower than on the upper end of each section. The stand of alfalfa was good on both fields, but not first-class.

#### IRRIGATION

The method of irrigation used in this experiment was that commonly known as the check or basin system of flooding. Heavy borders were thrown up around each plat and, wher-

and 15 forming group 3 and plats 10, 12, 14, and 16, group 4.

The experiments were to have been made with both well and river water, but the river went dry on March 30th and remained dry so long that the experimental work with river water had to be abandoned.

The several groups received the following depths of water during the season: Group 1, three inches every two weeks; group 2, six inches every four weeks; group 3, five inches every two weeks; and group 4, ten inches every four weeks. Thus field A would receive a total depth of six inches, and field B a total depth of ten inches, every four weeks.

#### Soil

The soil of both fields was a medium silt loam and as nearly identical in character as any two fields upon the station farm. The surface of the land in both fields was fairly even, but that of field A sloped so rapidly away from the irrigation ditch, that in order to

ever necessary to better control the water, cross borders were added. The water entered each plat at the upper end, spread out over the first section of the plat, passed through openings in the first cross border, spread out over the second section, and so on to the end of the plat. At the proper time the openings in each cross border were closed; thus each section was given its share of the water. The judgment of the irrigator was depended upon for the proper division of the water among the different sections of each plat. The distances from the pump to fields A and B were 1204 and 950 feet respectively. The weir for measuring the water, shown in Plate I, was located near the pump.

No allowance was made for loss by seepage and evaporation from the ditches leading to the fields, as it is believed that a comparatively small amount of water is lost in this way. The sediment in the river water effectually seals the ditches so that there is practically no seepage.

The distribution of the water was left largely to the judgment of an experienced irrigator, who was instructed to give each section its proper share of water. The growth of the alfalfa was not equally good upon all sections of each plat, but this difference might have been due to a variation in the amount of water applied or to a variation in the character of the soil of the different plats, or to both.

#### Harvesting

The alfalfa was cut a sufficient length of time before the irrigations for it to cure and be removed from the field. Excepting the first and last crops, the alfalfa was cut every four weeks. The hay from each plat was weighed separately. As nearly as was possible, the hay on all the plats was cured to the same degree of dryness. Every crop was harvested in good condition with the exception of the fourth, which was damaged by rain while it was in the swath. In order to irrigate at the proper time for the next cutting this crop was hauled in before it was cured, and thrown into small windrows in the corral, where it was allowed to remain until dry.

It was then gathered up and weighed. Under these circumstances there was, no doubt, an unavoidable loss of leaves, which, however, was probably about equal on all plats.

#### Field Notes

Field A, Group 1, Plats 1, 3, 5, and 7.

April 18.—Alfalfa showing need of water.

April 20.—Alfalfa showing effect of frost decidedly. Needs water badly on upper end of each section of each plat.

June 13.—Showing need of water. Nearly all parts of plats suffering for water.

September 15.—Showing insufficient water. Thereafter effect of fall rain showed in the condition of the group.

Field A, Group 2, Plats 2, 4, 6, and 8.

May 20.—Alfalfa shows effect of frost. Showing only slight need of water.

June 13.—Upper end of each section showing need of water.

September 15.—Insufficient water. Effect of rains beginning to show.

Field B, Group 3, Plats 9, 11, 13, and 15.

April 18.—Plats 9 and 11 lost a little water through gopher holes leading into old river bed before they could be stopped.

May 2.—Plat 11 lost a little water through gopher holes.

May 20.—Alfalfa shows effect of frost. Shows only slight need of water.

June 13.—Most of the alfalfa growing well but not rank, some spots showing need of water.

August 8.—Plats 9, 11, 13, and 15 lost a little water through gopher holes.

August 18.—Alfalfa seems to have plenty of water, but growth not as rank as it should be.

September 19.—Plats 9 and 11 lost a little water through gopher holes. The holes in each case were soon stopped.

Field B, Group 4, Plats 10, 12, 14, and 16.

May 20.—Alfalfa showing effect of frost.

June 13.—Appears to have plenty of water, but growth rather slow. Not as rank as it should be.

September 15.—Appeared to have plenty of water throughout season.

September 19.—Plat 12 lost a little water through gopher holes.

#### **Temperature of Irrigation Water**

The temperature of the water was taken at each irrigation, in the ditch just before it entered the field, and again near the center of the field just after the water had been turned into the next succeeding plat. The air temperature was obtained at the same time.







Table I shows the details of the irrigations.

Group 1.—This group received a depth of 3 inches of water every two weeks. It required a depth of 12 inches for the first cutting, 6 inches each for the second, third, and fourth cuttings, and 9 inches for the fifth cutting, or a total depth of 39 inches during the season.

Group 2.—This group was to have received the same quantity of water as group 1, except that it was to be applied once in four weeks instead of once every two weeks. Since the irrigations were begun later than on group 1, for the reason given elsewhere, this group received a total depth of only 36 inches during the season.

Group 3.—This group received a depth of 5 inches of water every two weeks. It required a depth of 20 inches to produce the first cutting, 10 inches each for the second, third, and fourth cuttings, and 15 inches for the fifth cutting, or a total of 65 inches during the season.

Group 4.—This group was to receive the same quantity of water as group 3, but it was to be applied every four weeks instead of every two weeks. For the same reason noted above, this group received a total depth of only 60 inches, as against 65 inches for group 3.

By a further study of Table I together with that of Table IV, we see that the cuttings of alfalfa that grow in early spring and late fall require more water and a much longer time in which to mature than those grown in mid-summer. This is due to several causes, chief among which is the cool nights. On groups 1 and 3 the first irrigation was given on April 4th, and it required twice as much water for the first cutting and one and one-half times as much for the last cutting as it required for either the second, third, and fourth cuttings; it also required twenty-one more days for the first and thirty-two more for the last cutting to mature than it did for any of the intervening cuttings. Since the soil was rather dry in the spring when the first irrigation was applied, it is probable that the excessive amount of water required for the first cutting can be accounted for, in part at least, by its be-

ing required to bring the soil to a normal condition of moisture for plant growth. The excessive amount used on the last cutting cannot, however, be so accounted for. The wind sweep during the spring months of 1904 was abnormally high, as will be seen by reference to Table XXII, and this condition undoubtedly still further retarded growth during that portion of the season.

Tables VII and VIII do not show so markedly the tendency to require longer time and more water for the first cutting in the spring and the last cutting in the fall as those mentioned above, yet they seem to show a tendency in that direction. The last cutting in the fall does not seem to be affected by adverse conditions so persistently as does the first cutting in the spring.

**Table II—Average Temperature of Well Water Used for Irrigation—  
1904**

Showing the monthly average temperatures of the air and water, the readings being taken where the water entered the field and again near the center of the field; also the average rise in temperature of the water as it spread out over the field.

| Month      | Air at Ditch | Water in Ditch | Air in Field | Water in Field | Average Rise in Water |
|------------|--------------|----------------|--------------|----------------|-----------------------|
| April..... |              | 63.8           |              | 66.1           | 2.3                   |
| May.....   | 81.6         | 66.2           | 82.2         | 69.8           | 3.6                   |
| June.....  | 86.8         | 67.9           | 87.3         | 73.9           | 6.0                   |
| July.....  | 87.5         | 65.0           | 87.5         | 69.4           | 4.4                   |
| August.... | 82.0         | 63.5           | 82.0         | 68.3           | 4.8                   |
| September  | 75.6         | 62.4           | 75.6         | 64.6           | 2.2                   |
| Average    | 82.7         | 64.8           | 82.9         | 68.7           | 3.9                   |

Table II shows the average temperatures of the air and the irrigation water used. There is a more or less common impression that the temperature of well water is so low as to be harmful to plants. It will be seen that the average temperatures are rather high, and further, that after the water has spread out over the surface of the land the average temperature is only 4.2° F. below the average air temperature. The water warms up considerably in its passage through the

ditches to the field and still more as it is distributed over each plat.

More light could be thrown upon this subject by taking temperature readings of the soil before and after each irrigation, and still further by results obtained with different temperatures of water under like conditions.

**Table III—Comparative Temperatures of Irrigation Waters**

Showing the monthly average temperatures of irrigation water in Utah during 1901 and in New Mexico during 1904.

| Date           | Utah | New Mexico |
|----------------|------|------------|
|                | ° F. | ° F.       |
| May.....       | 54.0 | 66.2       |
| June.....      | 54.0 | 67.9       |
| July.....      | 60.0 | 65.0       |
| August.....    | 62.0 | 63.5       |
| September..... | 54.0 | 62.4       |
| Average.....   | 56.8 | 65.0       |

Note—Utah, river water; New Mexico, well water.

Table III is a comparison between the temperature of well water in New Mexico and river water in Utah.\* It will be seen that there is an average of 8.4° F. in favor of the well water in New Mexico.

\*Bulletin No. 89, p. 84, Utah Agricultural Experiment Station.

**Table IV—Alfalfa—Period of Growth—1904**

Showing the date of each cut, and the period of growth for each cut and for the season, for each group of plats.

| Number of Cut             | Date of Cut     | Groups 1 and 3        | Groups 2 and 4*       |
|---------------------------|-----------------|-----------------------|-----------------------|
|                           |                 | Period of Growth Days | Period of Growth Days |
| First .....               | May 25.....     | 51                    | 23                    |
| Second .....              | June 24.....    | 30                    | 30                    |
| Third.....                | July 22.....    | 28                    | 28                    |
| Fourth.....               | August 19.....  | 28                    | 28                    |
| Fifth.....                | October 20..... | 62                    | 62                    |
| Total for the season..... | .....           | 197                   | 171                   |

\* First irrigation was given one month later on groups 2 and 4 than on groups 1 and 3, for reasons given elsewhere.

Table V—Alfalfa—Yields—1904

Showing the area of each plat, the yield for each cut and for the season, on each plat and each group of plats; and the yield per acre for each cut and for the season, on each plat and each group of plats.

|                                          | Field A   |           |           |           |           |           |           |           |           |            | Field B    |            |            |            |            |            |            |            |
|------------------------------------------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|------------|------------|------------|------------|------------|------------|------------|------------|------------|
|                                          | Group 1   |           |           |           |           | Group 2   |           |           |           |            | Group 3    |            |            |            | Group 4    |            |            |            |
|                                          | Plat<br>1 | Plat<br>3 | Plat<br>5 | Plat<br>7 | Plat<br>2 | Plat<br>4 | Plat<br>6 | Plat<br>8 | Plat<br>9 | Plat<br>11 | Plat<br>13 | Plat<br>15 | Plat<br>10 | Plat<br>12 | Plat<br>14 | Plat<br>16 | Plat<br>17 | Plat<br>18 |
| Area.....acres....                       | 1901      | 2204      | 2238      | 2150      | 1839      | 2211      | 2286      | 2450      | 2170      | 2067       | 1905       | 1750       | 2180       | 2062       | 1915       | 1747       |            |            |
| Yield, first cut, May 25.....pounds....  | 120       | 150       | 180       | 320       | 80        | 82        | 164       | 148       | 230       | 190        | 202        | 220        | 304        | 288        | 367        | 230        |            |            |
| Yield, second cut, June 24.....do.....   | 108       | 150       | 178       | 290       | 96        | 100       | 202       | 180       | 90        | 228        | 220        | 350        | 183        | 168        | 231        | 90         |            |            |
| Yield, third cut, July 22.....do.....    | 120       | 210       | 216       | 290       | 90        | 108       | 230       | 162       | 310       | 358        | 336        | 208        | 264        | 300        | 226        | 218        |            |            |
| Yield, fourth cut, August 19.....do..... | 158       | 226       | 140       | 410       | 152       | 222       | 340       | 240       | 254       | 270        | 820        | 472        | 308        | 256        | 344        | 430        |            |            |
| Yield, fifth cut, October 20.....do..... | 278       | 388       | 448       | 486       | 306       | 422       | 464       | 438       | 188       | 232        | 248        | 202        | 216        | 246        | 246        | 197        |            |            |
| Total for season.....do.....             | 784       | 1124      | 1162      | 1796      | 724       | 934       | 1420      | 1138      | 1062      | 1268       | 1316       | 1452       | 1175       | 1228       | 1424       | 1166       |            |            |
| Pounds per acre.....do.....              | 4146      | 5100      | 5092      | 7390      | 3933      | 4224      | 6212      | 4694      | 4832      | 6134       | 6908       | 8397       | 5380       | 5684       | 7231       | 6657       |            |            |
| Tons per acre.....do.....                | 2.07      | 2.56      | 2.65      | 3.67      | 1.91      | 2.11      | 3.10      | 2.31      | 2.44      | 3.06       | 3.45       | 4.15       | 2.70       | 2.99       | 3.66       | 3.33       |            |            |
| Average tons per acre for group..        |           |           |           | 2.72      |           |           |           | 2.36      |           |            |            | 3.28       |            |            |            | 3.17       |            |            |

Table V shows the detailed yields of each plat, and each group of plats, for each cutting, and the total for the season.

Comparing fields A and B we find that the yield is decidedly larger on field B, which received the larger quantity of water. There is only a slight difference in yield in favor of the more frequent irrigations. However this is true when the larger as well as the smaller quantity of water was applied.

**Table VI—Alfalfa—The Relation Between the Amount of Irrigation Water and the Yield—1904**

Showing the depth of water applied, the yield, and the depth of water required to produce one ton, for each cut and for the season, for each group.

| Number of<br>Cut      | Depth of Water, Inches |       | Y'ield, Tons |         | Depth of Water Applied<br>per Ton, Inches |        | Depth of Water, Inches |       | Y'ield, Tons |         | Depth of Water Applied<br>per Ton, Inches |       | Depth of Water, Inches |  | Y'ield, Tons |  | Depth of Water Applied<br>per Ton, Inches |  |
|-----------------------|------------------------|-------|--------------|---------|-------------------------------------------|--------|------------------------|-------|--------------|---------|-------------------------------------------|-------|------------------------|--|--------------|--|-------------------------------------------|--|
|                       | Group 1                |       |              | Group 2 |                                           |        | Group 3                |       |              | Group 4 |                                           |       |                        |  |              |  |                                           |  |
| First .....           | 12                     | .385  | 31.45        | 6       | .234                                      | 25.59  | 20                     | .411  | 48.66        | 10      | .529                                      | 18.89 |                        |  |              |  |                                           |  |
| Second .....          | 6                      | .363  | 16.53        | 6       | .274                                      | 21.89  | 10                     | .444  | 22.52        | 10      | .336                                      | 29.76 |                        |  |              |  |                                           |  |
| Third.....            | 6                      | .418  | 14.35        | 6       | .305                                      | 19.51  | 10                     | .601  | 16.64        | 10      | .504                                      | 19.84 |                        |  |              |  |                                           |  |
| Fourth .....          | 6                      | .467  | 12.85        | 6       | .477                                      | 12.58  | 10                     | .658  | 15.19        | 10      | .669                                      | 14.95 |                        |  |              |  |                                           |  |
| Fifth .....           | 9                      | .800  | 11.25        | 12      | .815                                      | 14.72  | 15                     | .435  | 22.42        | 20      | .458                                      | 43.72 |                        |  |              |  |                                           |  |
| Total for<br>season.. | 39                     | 2.433 | 16.03*       | 36      | 2.105                                     | 17.07* | 65                     | 2.549 | 23.36*       | 60      | 2.496                                     | 21.04 |                        |  |              |  |                                           |  |

\* Average.

In Table VI the results obtained by applying a definite amount of water to alfalfa at stated intervals are shown. The depth of water applied to each group during the growing season, the total yield, and the depth of water required to produce one ton of alfalfa on the four groups of plats are recorded as follows: Group 1 received 39 inches of water, yielded 2.43 tons of hay, and required 16.03 inches of water to produce one ton of hay. Group 2 received 36 inches of



water, yielded 2.10 tons of hay, and required 17.07 inches to produce a ton. Group 3 received 65 inches of water, yielded 2.55 tons of hay, and required 23.36 inches of water to produce a ton. Group 4 received 60 inches of water, yielded 2.50 tons of hay, and required 24.04 inches of water to produce one ton of hay. The group that received 36 inches of water required 1.04 inches of water more to produce each ton of hay than the group that received 39 inches of water; while the group that received the 39 inches of water required 8.01 inches less to make a ton than did the group that received 60 inches of water, and 7.33 inches less than the group that received 65 inches of water during the season. This indicates that either 39 inches of water is the most economical amount to apply under the conditions that existed this season, or that the best amount lies somewhere between 39 and 60 inches of water. The field notes indicate that the later is more likely to be true than the former, for the crop on the group that received 39 inches of water appeared to need more water than it received. The economy of using the smaller quantities of water is quite evident.

Whether it is best in a given case to use a small quantity or a liberal amount of water in the production of a crop will depend upon a number of factors, among which the following may be mentioned: The price and character of the land, the location of the land as regards markets, the character and number of accessible markets, the facilities for reaching important markets, the cost and supply of the water, the cost and supply of competent labor, the system of agriculture practised, etc., etc.

The information contained in the table will serve as a guide in the use of water, but in every case it will be desirable to determine the best quantity for a given soil and a given crop.

**COST OF ALFALFA GROWN WITH WELL WATER AND WITH  
RIVER WATER—1903-4****Plan**

In order to secure costs that would be representative of field practice, it was necessary to devote the whole of one field to each kind of water. Therefore two fields were selected, one containing 3.4 and the other 5.35 acres, and these fields were designated by the letters C and D respectively. Three plats of field D had to be thrown out of the experiment in 1904 on account of the wild grass in them, thus making the area of the fields 3.4 and 3.14 acres respectively for 1904. During the season of 1903 field C received well water and field D river water. The next season, 1904, field C was to have received the river water and field D the well water, but on account of the river's going dry on March 30th, field C which was to have received the river water, after remaining idle for upward of one month in the hope that the river water would come again, was irrigated with well water for the remainder of the season.

**Soil**

The soil of field C was somewhat lighter than that of field D,—the soil of the latter being a heavy adobe (clay). While the soils of the two fields have not as nearly like characteristics as was desired, yet the selection was about the best that could be made at the time. The surface of both fields was fairly even, but both sloped too rapidly for the proper distribution of the water. Cross borders were thrown in at frequent intervals in order to remedy this defect insofar as was possible.

**Irrigation**

The check or basin system of irrigation was followed. The irrigations were given whenever the crops seemed to need it. During the year 1903 the water was not measured, but the quantity applied, so far as possible, represented the common usage among alfalfa growers in the valley. During 1904 the water applied was measured. An experienced irrigator, Mr.

Santiago Apodaca, was in charge of the distribution of the water.

### Harvesting

The alfalfa was cut when it was between one-third and three-fourths full bloom. When thoroughly wilted it was raked into small windrows and allowed to finish curing. On the third or fourth day after cutting it was bunched, hauled in and stacked.

**Table VII—Alfalfa—Period of Growth—1903**

Showing the period of growth, for each cut and for the season.

| Number of Cut             | 1903        |                        |             |                        | 1904        |                        |             |                        |
|---------------------------|-------------|------------------------|-------------|------------------------|-------------|------------------------|-------------|------------------------|
|                           | Field C     |                        | Field D     |                        | Field C*    |                        | Field D     |                        |
|                           | Date of Cut | Period of Growth, days | Date of Cut | Period of Growth, days | Date of Cut | Period of Growth, days | Date of Cut | Period of Growth, days |
|                           |             |                        |             |                        |             |                        |             |                        |
| First.....                | May 20      | 36                     | May 20      | 49                     | June 9      | 15                     | May 20      | 49                     |
| Second.....               | July 2      | 43                     | July 7      | 48                     | July 14     | 35                     | June 29     | 40                     |
| Third.....                | Aug. 5      | 34                     | .....       | .....                  | Aug. 16     | 33                     | Aug. 8      | 40                     |
| Fourth.....               | Sept. 14    | 40                     | .....       | .....                  | Oct. 20     | 65                     | Oct. 13     | 55                     |
| Total for the season..... | .....       | 153                    | .....       | 97                     | .....       | 148                    | .....       | 195                    |

\* The alfalfa had made some growth in 1904 before the water was applied, as a result of rain and of water remaining in the soil from the previous year.

Note.—The period of growth for 1903 is figured from April 1 for Field D and April 14 for Field C. The delay with Field C was caused by the failure of the carpenter to complete the measuring weir on time. In 1904 the period of growth for Field C is figured from May 25, for reasons given elsewhere, and for Field D from April 1.

Table VII shows the length of time required for the growth of each cutting. There are a number of factors that influence, more or less, the length of the growing period of each cutting, chief among which are the quantity of water applied at each irrigation, the frequency of the irrigations,

the length of time between mowing and the application of the water for the next cutting, the day and the night temperatures, and the wind sweep,

**Table VIII—Alfalfa—Quantity of Water Applied—1904**

Showing the date of each irrigation; the depth of water applied at each irrigation and the depth of water applied for each cut and during the season.

| No. of Cut | Field C                |                                                |                                         | Field D                |                                                |                                         |
|------------|------------------------|------------------------------------------------|-----------------------------------------|------------------------|------------------------------------------------|-----------------------------------------|
|            | Date of Irrigation     | Depth of Water Applied each Irrigation, inches | Depth of Water Applied each Cut, inches | Date of Irrigation     | Depth of Water Applied each Irrigation, inches | Depth of Water Applied each Cut, inches |
| First ..   | May 25                 | 5.85                                           | 5.85                                    | April 1<br>April 25    | 6.81<br>3.79                                   | 10.60                                   |
| Second     | June 14<br>July 9      | 5.68<br>7.50                                   | 13.18                                   | May 24<br>June 9       | 5.75<br>4.54                                   | 10.29                                   |
| Third..    | July 21                | 5.63                                           | 5.63                                    | July 8<br>July 20      | 5.22<br>3.30                                   | 8.52                                    |
| Fourth     | August 19<br>August 24 | 6.06<br>4.70                                   | 10.76                                   | August 11<br>August 18 | 5.40<br>2.65                                   | 8.03                                    |
| Total..    | .....                  | .....                                          | 35.42                                   | .....                  | .....                                          | 37.45                                   |

Note—Field C was to have received river water. The river went dry March 30 and was still dry May 25; so well water was applied thereafter.

Table VIII shows in detail the quantity of water applied to the two fields, C and D,—the depth of water applied at each irrigation, the depth applied for each cutting, and the total depth applied for the four cuttings during the season. The average depth of water applied each irrigation throughout the season was 5.9 inches for Field C and 4.68 inches for Field D; the average depth of water applied for each cutting was 8.85 inches for Field C and 9.36 inches for Field D; and the total depth of water applied during the season was 35.42 inches for Field C and 37.46 inches for Field D. It is evident that Field C would have required more water than Field D if the first irrigation had been given on April 1, as in the case of Field D.

Table IX—Alfalfa—Cost of Irrigation—1903

Showing the time occupied in irrigating, the amount of fuel consumed, the cost of pumping, the cost of applying the water, and the total cost, per acre, for each irrigation, for each cut and for the season.

| No. of Irrigation                               | Date of Irrigation | Length of Run per acre hrs. min. | Coal Consumed per acre, pounds | Gasoline Consumed per acre, gals. | Cost of Pumping per acre* | Cost of Applying per acre | Total Cost per acre** |
|-------------------------------------------------|--------------------|----------------------------------|--------------------------------|-----------------------------------|---------------------------|---------------------------|-----------------------|
| Field C, 8.4 acres, irrigated with well water   |                    |                                  |                                |                                   |                           |                           |                       |
| First .....                                     | April              | 14-15                            | 1 41                           | 435                               | 1.64                      | .18                       | 1.77                  |
| Second ..                                       | April              | 27                               | 1 11                           | 295                               | 1.12                      | .09                       | 1.21                  |
| Third .....                                     | May                | 9                                | 1 10                           | 291                               | 1.11                      | .09                       | 1.20                  |
| Total for First Cut.....                        |                    | 4 2                              | 1021                           |                                   | 3.87                      | .31                       | 4.18                  |
| Fourth ....                                     | May                | 28-29                            | 1 22                           | 235                               | 1.08                      | .10                       | 1.20                  |
| Fifth .....                                     | June               | 9                                | 1 17                           | 268                               | 1.12                      | .10                       | 1.22                  |
| Total for Second Cut. ....                      |                    | 2 39                             | 524                            | 1.03                              | 2.31                      | .29                       | 2.51                  |
| Sixth .....                                     | July               | 8-9                              | 1 50                           | 398                               | 1.56                      | .14                       | 1.70                  |
| Seventh .                                       | July               | 29-30-31                         | 2 35                           | 418                               | 1.77                      | .20                       | 1.97                  |
| Total for Third Cut.....                        |                    | 4 26                             | 816                            |                                   | 3.33                      | .34                       | 3.67                  |
| Eighth ....                                     | August             | 10                               | 1 15                           | 212                               | .89                       | .09                       | .98                   |
| Ninth ....                                      | August             | 31                               | 1 39                           |                                   | 6.80                      | .18                       | 1.83                  |
| Total for Fourth Cut.....                       |                    | 2 54                             | 212                            | 8.80                              | 2.59                      | .22                       | 2.81                  |
| Total for season.....                           |                    | 14 1                             | 2573                           | 7.83                              | 12.11                     | 1.07                      | 13.18                 |
| Field D, 5.35 acres, irrigated with river water |                    |                                  |                                |                                   |                           |                           |                       |
| First .....                                     | March              | 26                               | 45                             |                                   |                           | .06                       | .06                   |
| Second ..                                       | April              | 15                               | 58                             |                                   |                           | .07                       | .07                   |
| Third.....                                      | April              | 27                               | 39                             |                                   |                           | .05                       | .05                   |
| Fourth ....                                     | May                | 9                                | 51                             |                                   |                           | .06                       | .06                   |
| Total for First Cut.....                        |                    | 3 13                             |                                |                                   |                           | .24                       | .24                   |
| Fifth .....                                     | May                | 29-30                            | 43                             |                                   |                           | .05                       | .05                   |
| Sixth.....                                      | June               | 9                                | 1 4                            |                                   |                           | .08                       | .08                   |
| Total for Second Cut.....                       |                    | 1 47                             |                                |                                   |                           | .13                       | .13                   |
| Total for season.....                           |                    | 5 00                             |                                |                                   |                           | .37                       | .37                   |

\* Cost of pumping includes coal at \$3 per ton and engineer at 20 cents per hour.

\*\* Total cost including coal at \$3 per ton, gasoline at 20 1-5 cents per gallon, engineer at 20 cents per hour, and man in field at 7½ cents per hour.

Table IX shows the results on fields C and D during 1903.

By striking averages we obtain the following: On field C irrigated with well water, it required 1 hour and 36 minutes to irrigate an acre, and it cost \$1.35 for pumping and 11½ cents for applying the water for each irrigation,—a total cost of \$13.18 per acre for the four cuttings. On field D irrigated with river water, it required 50 minutes to irrigate an acre, and it cost 6 cents to apply the water, or a total cost of 37 cents per acre for the two cuttings. Comparing these figures it will be seen that it cost \$12.81 more per acre for the well water than it cost for the river water, but to offset this large difference in the cost of irrigation, four cuttings were obtained from the well water as against two for the river water.

It will be seen also that the cost of applying the well water at each irrigation was almost double the cost of applying the river water. This difference was solely due to the fact that nearly double the quantity of river water was applied in a given time than of well water. Only about one-half as much well water was delivered into the irrigation ditch as the irrigator could handle. All that would be necessary to obliterate this difference would be to increase sufficiently the capacity of the pumping plant.

**Table X—Alfalfa—Cost of Irrigation—1904**

Showing the time occupied in irrigating, the amount of fuel consumed, the cost of pumping, the cost of applying the water, and the total cost, per acre, for each irrigation, for each cut and for the season.

| Number of<br>Irrigation                        | Date of Irrigation |       | Length of Run<br>per acre.<br>hrs. min. | Coal Con-<br>sumed<br>per acre.<br>pounds | Cost of<br>Pumping<br>per acre* | Cost of Applying<br>per acre | Total<br>Cost per<br>acre ** |
|------------------------------------------------|--------------------|-------|-----------------------------------------|-------------------------------------------|---------------------------------|------------------------------|------------------------------|
| Field C, 3.4 acres, irrigated with well water  |                    |       |                                         |                                           |                                 |                              |                              |
| First .....                                    | May                | 25    | 2 39                                    | 473                                       | \$ 1.83                         | \$ .20                       | \$ 2.03                      |
| Total for first Cut.....                       |                    |       | 2 39                                    | 473                                       | 1.83                            | .20                          | 2.03                         |
| Second.....                                    | June               | 14    | 2 34                                    | 440                                       | 1.73                            | .19                          | 1.92                         |
| Thlrđ.....                                     | July               | 9-11  | 3 23                                    | 468                                       | 1.97                            | .25                          | 2.22                         |
| Total for second Cut.....                      |                    |       | 5 57                                    | 908                                       | 3.70                            | .45                          | 4.14                         |
| Fourth.....                                    | July               | 21    | 2 33                                    | 400                                       | 1.61                            | .19                          | 1.80                         |
| Total for thlrđ Cut.....                       |                    |       | 2 33                                    | 400                                       | 1.61                            | .19                          | 1.80                         |
| Fifth.....                                     | August             | 19    | 2 44                                    | 312                                       | 1.40                            | .20                          | 1.60                         |
| Sixth.....                                     | August             | 24-25 | 2 8                                     | 308                                       | 1.27                            | .16                          | 1.43                         |
| Total for fourth Cut.....                      |                    |       | 4 52                                    | 620                                       | 2.67                            | .36                          | 3.03                         |
| Total for season.....                          |                    |       | 16 1                                    | 2401                                      | 9.81                            | 1.20                         | 11.00                        |
| Field D, 3.14 acres, irrigated with well water |                    |       |                                         |                                           |                                 |                              |                              |
| First .....                                    | April              | 1-2   | 3 4                                     | 607                                       | 2.28                            | .23                          | 2.51                         |
| Second.....                                    | April              | 25    | 1 43                                    | 300                                       | 1.17                            | .13                          | 1.30                         |
| Total for first Cut.....                       |                    |       | 4 47                                    | 907                                       | 3.45                            | .36                          | 3.81                         |
| Thlrđ.....                                     | May                | 24    | 2 36                                    | 462                                       | 1.73                            | .19                          | 1.97                         |
| Fourth.....                                    | June               | 9     | 2 3                                     | 384                                       | 1.47                            | .15                          | 1.62                         |
| Total for second Cut.....                      |                    |       | 4 39                                    | 846                                       | 3.25                            | .34                          | 3.59                         |
| Fifth.....                                     | July               | 8-9   | 2 21                                    | 340                                       | 1.40                            | .18                          | 1.58                         |
| Sixth.....                                     | July               | 20    | 1 29                                    | 207                                       | .87                             | .11                          | .98                          |
| Total for thlrđ Cut.....                       |                    |       | 3 50                                    | 547                                       | 2.27                            | .29                          | 2.56                         |
| Seventh.....                                   | August             | 11-12 | 2 25                                    | 338                                       | 1.57                            | .19                          | 1.76                         |
| Eighth.....                                    | August             | 18    | 1 12                                    | 152                                       | .65                             | .09                          | .74                          |
| Total for fourth Cut.....                      |                    |       | 3 38                                    | 540                                       | 2.22                            | .28                          | 2.50                         |
| Total for season.....                          |                    |       | 16 54                                   | 2840                                      | 11.19                           | 1.27                         | 12.46                        |

\* Cost of pumping includes engineer at 20 cents an hour and coal at \$5.50 per ton.

\*\* Total cost includes coal at \$5.50 per ton, engineer at 20 cents an hour, and man in the field at 7½ cents an hour.

Table X shows the same items for 1904 as does table IX for 1903.

Averaging the results for 1904, when both fields C and D were irrigated with well water, we obtain the following: It required for each irrigation per acre 2 hours and 40 minutes for field C and 2 hours and 5 minutes for field D; it cost for pumping \$1.63 for field C and \$1.45 for field D; and for applying it cost 20 cents for field C and 16 cents for field D, or a total cost per acre for the four cuttings obtained during the season of \$11.00 for field C and \$12.46 for field D.

It must be remembered that field D, was given two irrigations more than field C, which will account very largely for the difference in the total cost of the irrigation.

**Table XI—Alfalfa—Cost of Harvesting—1903**

Showing the time required for mowing, raking and bunching, and stacking; and the cost, per acre, for each cut and for the season.

| Number of Cut                                   | Time Mow-<br>ing per<br>acre<br>hrs. min | Time Rak-<br>ing and<br>Bunching<br>per acre<br>hrs. min. | Time<br>Stacking<br>per acre<br>hrs. min. | Total Time<br>hrs. min. | Total Cost<br>per acre |
|-------------------------------------------------|------------------------------------------|-----------------------------------------------------------|-------------------------------------------|-------------------------|------------------------|
| Field C, 3.4 acres, irrigated with well water   |                                          |                                                           |                                           |                         |                        |
| First.....                                      | 1 28                                     | 1 11                                                      | 4 25                                      | 7 4                     | \$ .53                 |
| Second.....                                     | 1 11                                     | 0 29                                                      | 6 24                                      | 8 4                     | .61                    |
| Third.....                                      | 1 25                                     | 0 44                                                      | 3 32                                      | 5 41                    | .42                    |
| Fourth.....                                     | 1 24                                     | 0 59                                                      | 5 31                                      | 7 54                    | .59                    |
| Total for Season.....                           | 5 28                                     | 3 23                                                      | 19 52                                     | 28 43                   | 2.15                   |
| Average.....                                    | 1 22                                     | 0 51                                                      | 4 56                                      | 7 11                    | .54                    |
| Field D, 5.35 acres, irrigated with river water |                                          |                                                           |                                           |                         |                        |
| First.....                                      | 1 7                                      | 0 45                                                      | 5 25                                      | 7 17                    | .55                    |
| Second.....                                     | 1 15                                     | 0 31                                                      | 5 35                                      | 7 21                    | .55                    |
| Total for Season.....                           | 2 22                                     | 1 16                                                      | 11 00                                     | 14 38                   | 1.10                   |
| Average.....                                    | 1 11                                     | 0 38                                                      | 5 30                                      | 7 10                    | .55                    |

NOTE—Teams and machinery not included in cost.



**Table XII—Alfalfa—Cost of Harvesting—1904**

Showing the time required for mowing, raking and bunching, and stacking; and the cost, per acre, for each cut and for the season.

| Number of Cut         | Time Mow-<br>ing per<br>acre<br>hrs. min. | Time Rak-<br>ing and<br>Bunching<br>per acre<br>hrs. min. | Time<br>Stacking<br>per acre<br>hrs. min. | Total Time<br>hrs. min. | Total Cost<br>per acre |
|-----------------------|-------------------------------------------|-----------------------------------------------------------|-------------------------------------------|-------------------------|------------------------|
| Field C               |                                           |                                                           |                                           |                         |                        |
| First.....            | 1 15                                      | 0 26                                                      | 2 15                                      | 3 56                    | \$ .30                 |
| Second.....           | 1 19                                      | 0 26                                                      | 4 42                                      | 6 27                    | .49                    |
| Third.....            | 1 19                                      | 0 53                                                      | 3 32                                      | 5 44                    | .43                    |
| Fourth.....           | 1 29                                      | 0 56                                                      | 2 34                                      | 4 59                    | .37                    |
| Total for Season..... | 5 22                                      | 2 41                                                      | 13 3                                      | 21 8                    | 1.59                   |
| Average.....          | 1 20                                      | 0 40                                                      | 3 16                                      | 5 16                    | .40                    |
| Field D               |                                           |                                                           |                                           |                         |                        |
| First.....            | 1 30                                      | 0 40                                                      | 1 32                                      | 3 42                    | .28                    |
| Second.....           | 1 21                                      | 0 31                                                      | 3 27                                      | 5 19                    | .40                    |
| Third.....            | 1 26                                      | 0 40                                                      | 6 32                                      | 8 38                    | .64                    |
| Fourth.....           | 1 8                                       | 1 7                                                       | 4 42                                      | 6 57                    | .52                    |
| Total for Season..... | 5 25                                      | 2 58                                                      | 16 13                                     | 24 36                   | 1.84                   |
| Average.....          | 1 21                                      | 0 45                                                      | 4 3                                       | 6 9                     | .46                    |

NOTE—Teams and machinery not included in cost.

Tables XI and XII show the items of time and cost of the different operations of harvesting the alfalfa on Fields C and D during the seasons of 1903 and 1904.

The average cost of harvesting during the two years was \$1.67 an acre, or 70 cents per ton.

**Table XIII—Alfalfa—Cost and Yield—1903**

Showing the cost of irrigating, the cost of harvesting, the total cost, the yield, and the cost per ton, per acre, for each cut and for the season.

| Number of Cut                       | Cost of<br>Irrigating<br>per acre | Cost of<br>Harvest-<br>ing per<br>acre | Total<br>Cost per<br>acre* | Yield<br>per acre,<br>tons | Cost per<br>ton |
|-------------------------------------|-----------------------------------|----------------------------------------|----------------------------|----------------------------|-----------------|
| Field C, irrigated with well water  |                                   |                                        |                            |                            |                 |
| First.....                          | \$ 4.17                           | \$ .53                                 | \$ 4.70                    | .648                       | \$ 7.25         |
| Second.....                         | 2.51                              | .61                                    | 3.12                       | 1.010                      | 3.09            |
| Third.....                          | 3.67                              | .42                                    | 4.09                       | .683                       | 6.46            |
| Fourth.....                         | 2.81                              | .59                                    | 3.40                       | .808                       | 4.20            |
| Total for Season.....               | 13.16                             | 2.15                                   | 15.31                      | 3.100                      | .....           |
| Average.....                        | 3.28                              | .54                                    | 3.83                       | .774                       | 4.94            |
| Field D, irrigated with river water |                                   |                                        |                            |                            |                 |
| First.....                          | .24                               | .55                                    | .79                        | .867                       | .91             |
| Second.....                         | .13                               | .55                                    | .68                        | .892                       | .76             |
| Total for Season.....               | .37                               | 1.10                                   | 1.47                       | 1.759                      | .....           |
| Average.....                        | .19                               | .55                                    | .74                        | .879                       | .84             |

\*Land tax, 59 cents, and ditch tax, 85 cents, not included.

**Table XIV—Alfalfa—Cost and Yield—1904**

Showing the cost of irrigating, the cost of harvesting, the total cost, the yield, and the cost per ton, per acre, for each cut and for the season.

| Number of Cut                       | Cost of<br>Irrigating<br>per acre | Cost of<br>Harvest-<br>ing per<br>acre | Total Cost<br>per acre | Yield<br>per acre,<br>tons | Cost per<br>ton |
|-------------------------------------|-----------------------------------|----------------------------------------|------------------------|----------------------------|-----------------|
| Field C, irrigated with well water  |                                   |                                        |                        |                            |                 |
| First .....                         | \$ 2.03                           | \$ .30                                 | \$ 2.33                | .354                       | \$ 6.58         |
| Second .....                        | 4.14                              | .49                                    | 4.63                   | .459                       | 10.08           |
| Third .....                         | 1.80                              | .43                                    | 2.23                   | .798                       | 2.79            |
| Fourth .....                        | 3.08                              | .37                                    | 3.40                   | .453                       | 7.50            |
| Total for Season .....              | 11.00                             | 1.59                                   | 12.59                  | 2.065                      | .....           |
| Average .....                       | 2.75                              | .40                                    | 3.15                   | .516                       | 6.10            |
| Field D, irrigated with river water |                                   |                                        |                        |                            |                 |
| First .....                         | 3.81                              | .28                                    | 4.09                   | .271                       | 15.09           |
| Second .....                        | 3.60                              | .40                                    | 4.00                   | .511                       | 7.82            |
| Third .....                         | 2.56                              | .64                                    | 3.20                   | .959                       | 3.33            |
| Fourth .....                        | 2.50                              | .62                                    | 3.02                   | .864                       | 3.49            |
| Total for Season .....              | 12.47                             | 1.94                                   | 14.41                  | 2.605                      | .....           |
| Average .....                       | 3.12                              | .48                                    | 3.60                   | .651                       | 5.49            |

NOTE—Land tax and ditch tax not included.

In Tables XIII and XIV the separate items of cost, the yield, and the cost per ton for each cutting are brought together and summarized for the season. In order to supply figures on the costs of harvesting alone, the items of land and water taxes are purposely omitted.

**Table XV—Alfalfa—Cost and Profit—1903 and 1904**

Showing the cost of growing alfalfa and placing it in the stack; the cost of growing alfalfa and placing it, baled, on board the cars; and the net profit, per acre, for the season.

|                                                | 1903                |                     | 1904                |                     |
|------------------------------------------------|---------------------|---------------------|---------------------|---------------------|
|                                                | Field C<br>per acre | Field D<br>per acre | Field C<br>per acre | Field D<br>per acre |
| <b>Alfalfa in stack:</b>                       |                     |                     |                     |                     |
| Irrigating .....                               | \$ 13.16            | \$ .37              | \$ 11.00            | \$ 12.47            |
| Mowing, raking, bunching and stacking .....    | 2.15                | 1.10                | 1.59                | 1.84                |
| Ditch tax .....                                |                     | .85                 |                     |                     |
| Land tax* .....                                | .59                 | .59                 | .54                 | .54                 |
| <b>Total cost.....</b>                         | <b>15.90</b>        | <b>2.91</b>         | <b>13.13</b>        | <b>14.85</b>        |
| <b>Alfalfa baled on board cars:</b>            |                     |                     |                     |                     |
| Irrigating .....                               | 13.16               | .37                 | 11.00               | 12.47               |
| Mowing, raking and bunching .....              | .66                 | .27                 | .60                 | .63                 |
| Baling at \$1.00 per ton .....                 | 3.10                | 1.76                | 2.07                | 2.60                |
| Hauling and loading on cars, at 35c p. t. .... | 1.08                | .62                 | .72                 | .91                 |
| Ditch tax .....                                |                     | .85                 |                     |                     |
| Land tax* .....                                | .59                 | .59                 | .54                 | .54                 |
| <b>Total cost.....</b>                         | <b>18.59</b>        | <b>4.46</b>         | <b>14.94</b>        | <b>17.15</b>        |
| Value of crop** .....                          | 31.00               | 17.60               | 30.59               | 39.07               |
| Net profit .....                               | 12.41               | 13.14               | 16.05               | 21.93               |
| Net profit per ton .....                       | 4.00                | 7.46                | 7.77                | 8.42                |

\* The land tax was based on a value of \$20.00 per acre at a tax rate of \$2.94 per \$100.00 in 1903 and \$2.70 in 1904.

\*\* The alfalfa was figured at the highest local market price, which was \$10.00 per ton in 1903 and \$15.00 per ton in 1904.

Table XV shows all of the items of cost of growing alfalfa and placing it in the stack, and placing it, baled, on board the cars, exclusive of horses and machinery, depreciation of value of equipment, and interest on the investment. The table also shows the value and profit per ton and per acre. The cost in the stack in 1903 was \$5.13 per ton for field C irrigated with well water, and \$1.66 per ton for field D irrigated with

river water. The cost baled and on board the cars was \$6.00 per ton for field C, and \$2.54 per ton for field D. The net profit on the alfalfa, baled and on board the cars, was \$12.41 per acre or \$4.00 per ton, for field C, and \$13.14 per acre or \$7.46 per ton, for field D.

In 1904 both fields received well water.

It is interesting to notice that while pumping for irrigation is a much more expensive method of supplying the water than from the river, yet the net profit from pumping was considerably more per acre in 1904 than when river water was used in 1903. This was due to the lack of river water for irrigation. During 1903 field D for this reason produced only two cuttings with a net profit per acre of \$13.14, and in 1904, when the river was dry until August, the same field under the pump gave a net profit of \$21.93 per acre. This shows that whenever there is a shortage in the river water then pumping for the irrigation of alfalfa is profitable. The figures showing the net profit per acre in Table XV indicate that two cutting from the river water will return about an equal net profit per acre as well water applied the whole season and securing four or five cuttings. Any fluctuation in the market demand causing a like fluctuation in the price would, of course, cause the relative profit on alfalfa grown by well and river water to vary.

**Table XVI—Alfalfa—Cost and Profit With River and Well Water Combined—1903**

Showing the items of cost and profit per acre when using river water for irrigating the first and second cuts and well water for irrigating the third and fourth cuts.

|                                            | Cost Per Acre                |                             | Total Cost with Both River and Well Water |
|--------------------------------------------|------------------------------|-----------------------------|-------------------------------------------|
|                                            | River Water 1st and 2nd Cuts | Well Water 3rd and 4th Cuts |                                           |
| Irrigation.....                            | \$ .37                       | \$ 6.47                     | \$ 6.84                                   |
| Mowing, raking and bunching.....           | .27                          | .34                         | .61                                       |
| Baling at \$1.00 per ton.....              | 1.76                         | 1.44                        | 3.20                                      |
| Hauling to cars at 35 cents per ton.....   | .62                          | .50                         | 1.12                                      |
| Ditch tax.....                             | .85                          | .....                       | .85                                       |
| Land tax.....                              | .59                          | .....                       | .59                                       |
| Total.....                                 | 4.46                         | 8.75                        | 13.21                                     |
| Total returns alfalfa at \$10 per ton..... | 17.60                        | 14.41                       | 32.01                                     |
| Net profit per acre.....                   | 13.14                        | 5.66                        | 18.80                                     |

Note—The above table was compiled from the results obtained from both Field C and Field D.

Table XVI shows more fully the benefit derived from supplementing the river flow by pumping in times of shortage. It will be seen that the net profit in 1903 from two cuttings of alfalfa grown with river water was \$13.14 per acre. The river water failing at this time, two more cuttings were secured by pumping the water, with an additional net profit of \$5.66 per acre, making a total net profit of \$18.80 per acre when well water was used to supplement the river water.

**Cost of Pumping Water for the Irrigation of Wheat—1904**  
**Plan**

The data on the cost of pumping water for the irrigation of wheat were secured in connection with experimental work in soil moisture, which was carried on in cooperation with the Department of Soils. The following diagram shows the arrangement of the plats and groups of plats:

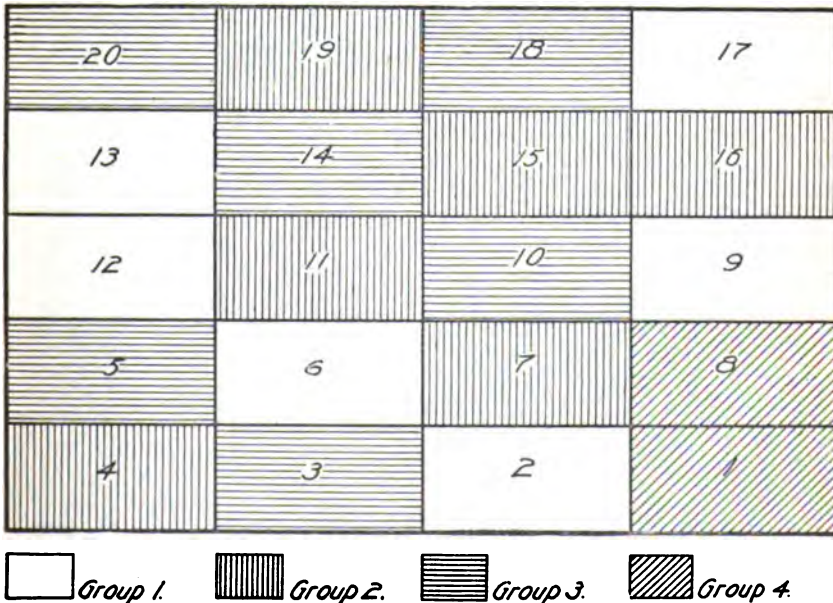


Fig. 3. Plat of Wheat.—Vernon, Bulletin 158, Office of Experiment Stations, Irrigation and Drainage Investigations, United States Department of Agriculture.

There were twenty plats of wheat of about one-tenth acre each, all of which were given an equal quantity of water up to the time of heading. They were all irrigated on January 5 to produce germination; on April 19, when spring growth began; and on May 18, at which time the wheat was beginning to head. After heading, the plats were divided into four groups, of which the first three contained six plats each and the fourth

contained two plats. The groups were irrigated as follows: Group 1 was irrigated every week after heading; group 2, every two weeks; group 3, every three weeks; and group 4, not at all. A depth of six inches of water was applied at each irrigation up to and including the one given at the time of heading. Thereafter, the depth of water applied was variable, as shown in Table XVII. It is probable that if the land had been quite level, less water would have been required to properly irrigate each plat. However, the condition of the land was typical of the valley,—wheat lands seldom or never being in as good condition for irrigation as alfalfa lands.

#### **Soil and Preparation of the Seed Bed**

The soil was variable, ranging from a rather heavy sandy loam on the west side to a heavy adobe (clay) on the east side. The plats that composed each group were selected so as to counteract this variability in the character of the soil, as will be seen by reference to the diagram.\* The surface of the land was rather uneven. The land was plowed to a depth of about five inches on December 8 and 9, 1903. It was then thoroughly pulverized and leveled by means of a rectangular frame made of 2 x 12 inch lumber set on edge.

#### **Seeding**

On December 22, 1903, 2 bushels of wheat were sown per acre, about  $1\frac{1}{2}$  inches deep. A press drill was used, and the drills were 8 inches apart. The variety sown, Algerian White (Station No. 410), has very large kernels and, for this reason, 2 bushels per acre were sown instead of  $1\frac{1}{2}$ , the amount usually sown of other varieties.

#### **Irrigation**

The check or basin system of irrigation was followed, which has been fully described heretofore in these pages.

It is believed that four or five inches of water instead of six

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\* For a more complete description of the soil of the different plats see Bulletin No. 54 of this Station.



inches would have given practically the same yield of wheat if the ground had been perfectly level.

#### Harvesting and Threshing

The wheat was cut on June 25, 1904, with a Champion Self-binder, and threshed with a Heebner & Son's (Lansdale, Pa.) Little Giant Thresher. The wheat was shocked and allowed to dry for a week or ten days, after which it was hauled to the machine and threshed, the quantity of straw and grain from each plat being recorded. The total time the crop occupied the ground was 186 days—from December 22, 1903, to June 25, 1904—while it made nearly all of its growth above the ground between April 19 and the time of ripening, or 67 days.

#### Field Notes

April 1.—Good stand on all plats. Rabbits pasturing on south tier of plats.

May 1.—All plats appear about alike. Effects of pasturing of rabbits practically overcome.

May 18.—Beginning to head.

May 25.—Heads well out. Beginning to bloom.

June 1.—Beginning to fill.

June 8.—Watery stage. Grain nearly full size.

June 15.—Milk stage. Grain full size.

June 22.—Dough stage. Ripening.

June 25.—Ripe enough to cut.

**Table XVII—Wheat—Quantity of Water Applied—1904**

Showing the date and number of each irrigation; the depth of water applied to each plat at each irrigation and during the season; and the average depth of water applied to each group during the season.

| Date of Irrigation                             |                  | Jan. 5 | Apr. 19 | May 18 | May 25 | June 2 | June 8 | June 15 | Total |
|------------------------------------------------|------------------|--------|---------|--------|--------|--------|--------|---------|-------|
| Number of Irrigation                           |                  | 1      | 2       | 3      | 4      | 5      | 6      | 7       | 7     |
| Depth Inches                                   |                  |        |         |        |        |        |        |         |       |
| Irrigated once each week after heading         |                  |        |         |        |        |        |        |         |       |
| Group I                                        | Plat No. 2.....  | 6      | 6       | 6      | 5      | 4      | 4      | 4       | 35    |
|                                                | Plat No. 6.....  | 6      | 6       | 6      | 5      | 4      | 4      | 4       | 35    |
|                                                | Plat No. 9.....  | 6      | 6       | 6      | 5      | 4      | 4      | 4       | 35    |
|                                                | Plat No. 12..... | 6      | 6       | 6      | 5      | 4      | 4      | 4       | 35    |
|                                                | Plat No. 13..... | 6      | 6       | 6      | 5      | 4      | 4      | 4       | 35    |
|                                                | Plat No. 17..... | 6      | 6       | 6      | 5      | 6      | 4      | 4       | 37    |
|                                                | Average.....     | 6      | 6       | 6      | 5      | 4.3    | 4      | 4       | 35.3  |
| Irrigated once every two weeks after heading   |                  |        |         |        |        |        |        |         |       |
| Group II                                       | Plat No. 4.....  | 6      | 6       | 6      | .....  | 6      | .....  | 5       | 29    |
|                                                | Plat No. 7.....  | 6      | 6       | 6      | .....  | 6      | .....  | 5       | 29    |
|                                                | Plat No. 11..... | 6      | 6       | 6      | .....  | 6      | .....  | 6       | 30    |
|                                                | Plat No. 15..... | 6      | 6       | 6      | .....  | 6      | .....  | 5       | 29    |
|                                                | Plat No. 16..... | 6      | 6       | 6      | .....  | 6      | .....  | 5       | 29    |
|                                                | Plat No. 19..... | 6      | 6       | 6      | .....  | 6      | .....  | 5       | 29    |
|                                                | Average.....     | 6      | 6       | 6      | .....  | 6      | .....  | 5.2     | 29.2  |
| Irrigated once every three weeks after heading |                  |        |         |        |        |        |        |         |       |
| Group III                                      | Plat No. 3.....  | 6      | 6       | 6      | .....  | .....  | 6      | .....   | 24    |
|                                                | Plat No. 5.....  | 6      | 6       | 6      | .....  | .....  | 6      | .....   | 24    |
|                                                | Plat No. 10..... | 6      | 6       | 6      | .....  | .....  | 6      | .....   | 24    |
|                                                | Plat No. 14..... | 6      | 6       | 6      | .....  | .....  | 6      | .....   | 24    |
|                                                | Plat No. 18..... | 6      | 6       | 6      | .....  | .....  | 6      | .....   | 24    |
|                                                | Plat No. 20..... | 6      | 6       | 6      | .....  | .....  | 6      | .....   | 24    |
|                                                | Average.....     | 6      | 6       | 6      | .....  | .....  | 6      | .....   | 24    |
| Not irrigated after heading                    |                  |        |         |        |        |        |        |         |       |
| Group V                                        | Plat No. 1.....  | 6      | 6       | 6      | .....  | .....  | .....  | .....   | 18    |
|                                                | Plat No. 8.....  | 6      | 6       | 6      | .....  | .....  | .....  | .....   | 18    |
|                                                | Average.....     | 6      | 6       | 6      | .....  | .....  | .....  | .....   | 18    |

By reference to Table XVII the quantity of water applied to each individual plat or group of plats may be found.

**Table XVIII—Wheat—Cost, Yield, and Duty of Water—1904**

Showing the depth of water applied before and after heading, the total depth of water applied during the growth of the crop, the yield per acre of grain and straw, the depth of water required to produce one bushel of grain, the length of run, the quantity of coal consumed, the cost of pumping per bushel of grain, and the cost of pumping per acre, for each group.

|                                                                       | Group 1            | Group 2            | Group 3           | Group 4           |
|-----------------------------------------------------------------------|--------------------|--------------------|-------------------|-------------------|
| Depth of water applied before heading—Inches.                         | 18                 | 18                 | 18                | 18                |
| Depth of water applied after heading....do....                        | 17.3               | 11.2               | 6                 |                   |
| Total depth of water applied.....do....                               | 35.3               | 29.2               | 24                | 18                |
| Yield of grain per acre.....bushels....                               | 18                 | 16.6               | 15.1              | 10.6              |
| Yield of straw per acre.....pounds....                                | 1947               | 1901               | 1450              | 1207              |
| Depth of water required to produce one bushel of grain.....inches.... | 1.96               | 1.76               | 1.52              | 1.70              |
| Time pumping.....                                                     | hrs. min.<br>16 15 | hrs. min.<br>11 51 | hrs. min.<br>9 51 | hrs. min.<br>3 32 |
| Fuel consumed.....pounds...                                           | 2135               | 1766               | 1456              | 383               |
| Cost of pumping per acre*.....                                        | \$ 10.61           | \$ 8.41            | \$ 6.96           | \$ 5.21           |
| Cost of pumping per bushel of grain*.....                             | .51                | .51                | .46               | .49               |
| Value of grain per acre, at 2c per pound or \$1.20 per bushel.....    | \$ 21.60           | 19.92              | 18.12             | 12.72             |

\* Including the cost of the fuel and the engineer.

NOTE—Owing to the shortage of water wheat was practically a failure in the valley, which accounts for the high price.

From an inspection of Table XVIII it will be seen that of the different quantities of water applied during the growth of the crop, 35.3, 29.2, 24, and 18 inches to groups 1, 2, 3, and 4, respectively, the group which received 24 inches gave the highest return in wheat per inch of water. The quantity of water required to produce one bushel of grain, 1.96, 1.76, 1.52, and 1.70 inches for the different groups, leads to the same conclusion that 24 inches of water was the best amount to apply under the conditions prevailing. The same conclusion is reached when the cost of pumping per bushel of grain on the different groups is compared.

Comparing group 1 with 3, and 2 with 3 as to yields and cost of pumping, we find that the increase in the yield on groups 1 and 2 over the yield on group 3 is a trifle more than

enough in each case to offset the increase in the cost of pumping,—there being a balance of 35 cents and 56 cents respectively in their favor.

### **Cost of Pumping Water for the Irrigation of Corn—1904**

#### **Plan**

The data upon which are based the cost of pumping water for the irrigation of corn were obtained in connection with a fertilizer experiment which was carried on in cooperation with the Department of Chemistry. The field contained 1.43 acres. The water was applied when the crop seemed to need it, five irrigations being given during the growing period of the crop. The first irrigation was given on May 19, to produce germination; the second was given on May 28; the third on June 22; the fourth on July 13; and the fifth on August 4.

#### **Soil and Preparation of the Seed Bed**

The soil was a heavy silt loam. The surface of the land was even but sloped rather too rapidly from the irrigation ditch to secure an even distribution of the water on all parts. Several cross borders were thrown in, which assisted in preventing the water from settling to the lower end of each plat. The land was plowed May 12 and 13 to a depth of about 5 inches, disced once and harrowed three times with an Acme harrow, and smoothed with the smoother heretofore mentioned under "wheat."

#### **Planting**

The corn was drilled with a 2-horse corn planter on May 18 to a depth of from 2 to 2½ inches. The kernels were dropped 16 inches apart in the row and the rows were 3 feet 8 inches apart.

#### **Cultivation**

The corn was hoed once between June 1 and 6, and plowed with a Planet Jr., cultivator on June 30 and again on July 23.

**Irrigation**

The check or basin system of irrigation was employed.

**Harvesting**

The corn was cut and shocked on September 16, when it was beginning to mature. It remained in the field until November 26, when it was hauled in, weighed, and immediately shucked, the weight of the stover and grain being recorded. The total period of growth was 120 days, from May 18 to September 16. If the corn had been allowed to stand until ripe, the time it occupied the land would have been somewhat lengthened, but no additional water would have been required.

**Table XIX—Corn—Cost of Irrigation—1904**

Showing the date and number of each irrigation; the depth of water applied; the length of run; the quantity of fuel consumed; the cost of pumping; the cost of applying the water; and the total cost, per acre, for each irrigation and for the season.

| Number of<br>Irrigation                                                      | Date of<br>Irrigation | Depth of<br>Water<br>Applied,<br>inches | Length<br>of Run<br>per acre<br>hrs. min. | Coal<br>Con-<br>sumed*<br>per acre,<br>pounds | Cost of<br>Pumping<br>per acre | Cost of<br>Applying<br>Water<br>per acre | Total<br>Cost of<br>Irriga-<br>tion per<br>acre |
|------------------------------------------------------------------------------|-----------------------|-----------------------------------------|-------------------------------------------|-----------------------------------------------|--------------------------------|------------------------------------------|-------------------------------------------------|
| First.....                                                                   | May 19                | 6.18                                    | 2 48                                      | 420                                           | \$ 1.71                        | \$ .21                                   | \$ 1.92                                         |
| Second.....                                                                  | May 28                | 4.50                                    | 2 2                                       | 306                                           | 1.24                           | .15                                      | 1.39                                            |
| Third.....                                                                   | June 22               | 4.63                                    | 2 6                                       | 315                                           | 1.29                           | .16                                      | 1.45                                            |
| Fourth .....                                                                 | July 13               | 6.06                                    | 2 44                                      | 411                                           | 1.62                           | .20                                      | 1.82                                            |
| Fifth .....                                                                  | August 4              | 3.86                                    | 1 45                                      | 262                                           | 1.06                           | .13                                      | 1.19                                            |
| Total for season.....                                                        |                       | 25.22                                   | 11 25                                     | 1714                                          | 6.92                           | .85                                      | 7.27                                            |
| Yield per acre: Grain, 31.9 bushels; stover, 6521 pounds; value.....\$ 36.27 |                       |                                         |                                           |                                               |                                |                                          |                                                 |

\* Estimated from long runs on alfalfa.

Note—The grain was valued at 1½c. per pound shelled, and the stover was estimated at \$2.00 per ton.

Table XIX shows that the corn received a depth of 25.2 inches of water in five irrigations; that it cost \$6.92 an acre for the pumping, 85 cents an acre for applying, and a total of \$7.77 an acre for the season's irrigations. This table also shows that there was a yield of 31.9 bushels, or 1786 pounds,

of corn per acre, and a trifle over  $3\frac{1}{4}$  tons, or 6521 pounds, of stover per acre.

The corn was worth on the local market  $1\frac{1}{2}$  cents per pound, and the value of the stover was reckoned at \$2.00 per ton, making a return of \$29.77 per acre for the grain, \$6.50 for the stover, or a total return of \$36.27 an acre.

### **Cost of Pumping Water for the Irrigation of Sweet Potatoes—**

**1904**

#### **Plan**

A field of 1.1 acres near the pump was selected for the sweet potato crop. The irrigation water was applied as often as the crop seemed to demand it.

#### **Soil and Preparation of the Seed Bed**

The soil was a heavy clay, not well adapted to growing sweet potatoes, but this was the least objectionable land available. The land was plowed to a depth of about 6 inches, thoroughly pulverized, and immediately thrown into ridges ready for planting.

#### **Planting**

The plants were set on June 13, about midway up the sides of the ridges, near the water line. In setting, the roots of the plants were pushed into the mellow soil with a wedge-shaped stick. An irrigation was given within two hours after setting so as to prevent wilting and loss of plants.

#### **Cultivation**

The rows were hand-hoed once, and the middles cultivated twice with a plow, before the vines covered the intervening spaces. After the vines had matted between the rows they were lifted from the ground once in order to check their tendency to root at the nodes.

#### **Irrigation**

The furrow system of irrigation was used. The water was run between the ridges until the furrows were about one-half full.

**Harvesting**

The potatoes were harvested between November 1 and 8. The vines were cut off at the surface of the ridges with a hoe and raked into the middles. The potatoes were thrown out with a small stirring plow. Those not removed by the plow were dug with a fork. When dug the potatoes were placed in piles and kept covered with vines at night so as to protect them from frost. After they had remained in the field a few days to dry, they were hauled in and weighed.

The total period of growth was 124 days, and the yield of unsorted potatoes 10,000 pounds per acre.

**Table XX—Sweet Potatoes—Cost and Profit—1904**

Showing the date and number of each irrigation; the depth of water applied; the length of run; the quantity of fuel consumed; and the cost of pumping, per acre, for each irrigation and for the season; also the yield per acre.

| Number of Irrigation   | Date of Irrigation | Depth of Water Applied, inches | Length of Run per acre hrs. min. | Coal Consumed* per acre, pounds | Cost of Pumping per acre | Cost of Applying Water per acre | Total Cost of Irrigation per acre |
|------------------------|--------------------|--------------------------------|----------------------------------|---------------------------------|--------------------------|---------------------------------|-----------------------------------|
| First.....             | June 13            | 4.28                           | 2 24                             | 325                             | \$ 1.37                  | \$ .18                          | \$ 1.55                           |
| Second.....            | July 23            | 5.34                           | 2 59                             | 407                             | 1.72                     | .22                             | 1.94                              |
| Third.....             | August 5           | 3.50                           | 1 26                             | 195                             | .82                      | .11                             | .93                               |
| Fourth.....            | August 16          | 4.50                           | 1 45                             | 236                             | 1.00                     | .13                             | 1.13                              |
| Total for season. .... |                    | 17.62                          | 8 34                             | 1163                            | 4.91                     | .64                             | 5.55                              |

\* Fuel estimated.

Note—Yield per acre, 10,000 pounds; value, \$170.00 per acre, the potatoes being sold at \$1.70 per hundred pounds.

From Table XX we learn that the sweet potato crop received only 17.6 inches of water, which was applied in four irrigations. The cost of pumping was \$4.91, the cost of applying the water 64 cents, and the total cost of irrigation \$5.55 per acre. The yield was 10,000 pounds per acre, valued at \$170.00. However, a good many of the potatoes were sold for more than \$1.70 a hundred pounds and none for less.

**Meteorological Conditions****Table XXI—Meteorological Conditions for the Year 1904**

Showing the mean temperature, relative humidity, wind movement and precipitation for the months of April to October, inclusive, 1904; and compares the averages for 1904 with the averages of the same months for the six preceding years 1898 to 1903, inclusive.

| Month                                                                      | Mean Temperature | Relative Humidity | Wind Movement* | Rainfall |
|----------------------------------------------------------------------------|------------------|-------------------|----------------|----------|
| April.....                                                                 | 60.8             | 13.               | 9.9            | .60      |
| May.....                                                                   | 68.1             | 18.               | 9.5            | .05      |
| June.....                                                                  | 77.1             | 25.               | 9.9            | .70      |
| July.....                                                                  | 79.6             | 33.               | 9.1            | 1.36     |
| August.....                                                                | 77.4             | 43.               | 7.1            | 1.24     |
| September.....                                                             | 70.6             | 58.               | 7.1            | 4.02     |
| October.....                                                               | 60.3             | 56.               | 6.8            | 1.52     |
| Average, 1904, April to October, inclusive.....                            | 70.6             | 35.               | 8.5            | 8.89     |
| Average for six years, 1898 to 1903, from April to October, inclusive..... | 69.3             | 43.               | 7.2            | 8.30     |

\* Average hourly movement in miles per hour.

NOTE.—The above table was supplied by Professor J. D. Tinsley, Station Meteorologist.

Table XXI shows the mean temperature, the relative humidity, the wind velocity, and the precipitation for the growing season of 1904; and compares the average results for 1904 with an average of the results of the six preceding years, 1898 to 1903, inclusive.

By an inspection of the table we see that the mean temperature of the growing season of 1904 was practically the same as the average mean temperature of the six preceding years; and that the relative humidity was much lower, the wind velocity somewhat higher, and the rainfall only a trifle higher than the average of the six preceding years. We also see that the relative humidity and precipitation were higher during the last three months, and the wind velocity higher during the first four months than at any other portion of the growing season.



Table XXII—Record of Daily Rainfall—1904

Showing the inches of rainfall each day of the year

| Day of Month | Jan. | Feb. | Mch. | Apr. | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. |
|--------------|------|------|------|------|-----|------|------|------|-------|------|------|------|
| 1.....       |      |      |      |      |     |      | .72  | .30  |       | .60  |      |      |
| 2.....       |      |      |      |      |     |      |      | .07  | .19   |      |      |      |
| 3.....       |      |      |      |      |     |      |      |      | .15   |      |      |      |
| 4.....       |      |      |      |      |     |      |      | .10  | .12   |      | .50  | .63  |
| 5.....       |      |      |      |      |     |      |      | T    | T     |      |      |      |
| 6.....       |      |      |      |      |     |      |      | .09  |       |      |      |      |
| 7.....       | T    |      |      |      |     | T    |      |      | .22   | .41  |      |      |
| 8.....       |      |      |      |      |     |      | T    |      |       | .10  |      |      |
| 9.....       |      |      |      |      |     |      |      |      |       |      |      |      |
| 10.....      |      |      |      |      |     |      |      |      |       |      |      |      |
| 11.....      |      |      |      |      | T   |      | T    |      |       |      |      |      |
| 12.....      |      |      |      |      |     |      | T    |      | 1.29  |      |      |      |
| 13.....      |      |      |      |      |     | .12  |      | .07  | .07   |      |      |      |
| 14.....      |      |      |      |      |     | .03  |      | .15  |       | .12  |      |      |
| 15.....      |      |      |      |      | .02 |      | T    |      |       |      |      |      |
| 16.....      |      |      |      |      |     | T    |      |      |       |      |      |      |
| 17.....      |      |      |      |      |     | T    | .15  | T    |       |      |      |      |
| 18.....      |      | T    |      |      |     | T    | .26  |      |       |      |      |      |
| 19.....      |      | .10  |      |      | T   |      |      | T    |       |      |      |      |
| 20.....      |      | .01  |      |      |     |      | T    | T    | .41   |      |      |      |
| 21.....      |      |      |      |      |     |      | .18  |      |       |      |      |      |
| 22.....      |      |      |      |      |     |      |      | .08  |       |      |      |      |
| 23.....      |      |      |      |      |     |      |      |      | T     |      |      |      |
| 24.....      |      |      |      |      | .03 |      |      |      |       | .17  |      |      |
| 25.....      |      |      |      |      |     | T    |      |      |       |      |      |      |
| 26.....      |      |      |      |      |     | .55  | .05  | .43  | T     |      |      |      |
| 27.....      |      |      |      |      |     |      |      |      | T     |      |      |      |
| 28.....      |      |      |      |      |     |      |      |      |       | T    |      |      |
| 29.....      |      |      |      |      |     | T    |      |      | 1.63  | .02  |      |      |
| 30.....      |      |      |      |      |     | T    |      |      |       | .10  |      |      |
| 31.....      |      |      |      |      |     |      |      |      |       |      |      |      |
| Total.....   | T    | .11  |      |      | .05 | .70  | 1.36 | 1.24 | 4.02  | 1.52 | .50  | .63  |

Note—Compiled from records supplied by the meteorologist.

Table XXII shows the daily rainfall for the year 1904. It will be seen that on many days there was only a trace of rain or only a few hundredths of an inch, probably not sufficient to noticeably affect the growth of the crop. Out of a total of 62 rainy days, including those when only a trace of rain fell, on 36 of these less than 1-10 of an inch fell, on 50 less than 25-100 of an inch fell, and on 55 less than  $\frac{1}{2}$  of an inch of rain fell. Exclusive of two days upon which rain fell in November and December, upon only 5 days was there a rainfall of  $\frac{1}{2}$  an inch and on only two of those was there a rainfall of an inch or more. It is probable that the rainfall affected the crop very little and then principally during the growth of the last cutting.

#### ACKNOWLEDGMENTS

Acknowledgment is due the different members of the Station Staff for suggestions and assistance from time to time. The Atchison, Topeka & Santa Fe Railway has kindly extended courtesies in the way of freight on engines and other experimental equipment. The use of material from other sources is acknowledged in the body of the bulletin.

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**BULLETIN NO. 57**

JANUARY, 1906

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**New Mexico College of Agriculture and Mechanic Arts**

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**AGRICULTURAL EXPERIMENT STATION**

**AGRICULTURAL COLLEGE, N. M.**

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**STEER FEEDING**

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**BY**

**J. J. VERNON and J. M. SCOTT.**

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SANTA FE, N. M.:  
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# NEW MEXICO AGRICULTURAL EXPERIMENT STATION

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and to others as far as the editions printed will allow  
on application to the Director

## **SUMMARY AND CONCLUSIONS**

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1. The steers fed alfalfa hay only gave a larger return per ton for the alfalfa eaten, a larger net profit, and cheaper beef than those given a grain ration in addition to the alfalfa hay.

2. The steers fed a ration composed of alfalfa hay, wheat, and bran made larger average daily gains per thousand pounds live weight, and required less roughage per day than the steers which received alfalfa hay only.

3. In 1904-5 the steers fed only alfalfa hay gave a larger return per ton for the alfalfa eaten than those which received an additional ration of grain with the alfalfa hay. The reverse is true of the steers fed during 1902-3, when the grain-fed steers gave the larger return for the alfalfa eaten. It is evident that further tests will be necessary for the elucidation of this point.

4. It requires a longer feeding period in which to fit steers for the market when feeding alfalfa hay alone than when a grain ration is fed with the alfalfa hay.

5. The shrinkage caused by dehorning was very slight and its effect lasted only about one week.

## **STEER FEEDING—1904-5**

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### **Introduction**

The feeding experiment carried on during the winter of 1904-5 is a continuation of the investigations of 1901-2 and 1902-3. The results of the previous investigations have been published in bulletin No. 50 of this Station. The present experiment was undertaken primarily for the purpose of securing further data on the comparative value of the rations alfalfa with grain and alfalfa alone for fitting range-grown steers for the local markets.

### **EQUIPMENT**

It will be unnecessary to give a description of the equipment and method of handling, since a complete description may be found on pages 9 and 10 of bulletin No. 50 of this Station.

### **DESCRIPTION OF STEERS**

The steers for the experiment of the winter of 1904-5, consisting of ten head of two year-olds, were purchased from Mr. J. D. Isaacks, of Las Cruces, New Mexico. The steers were raised on his range located in and west of the Organ mountains. The purchase was made just before the feeding test began. The steers were driven in from the Mountains on January 28, a distance of about fifteen miles, and immediately weighed without feed or water. The steers were all dehorned at the time the feeding test began.

### **PRICES**

The price paid was \$2.75 per hundred pounds on foot. They brought \$3.25 per hundred pounds live weight when sold on the local market.

### **DIVISION**

The steers were divided into two lots of five steers each, as nearly equal in weight and quality as possible. (See Plates

I and II). The weights given are averages of three daily weighings. Each lot was weighed at the beginning of the test and once a month thereafter, to the end of the test. The weighings were made at 9 o'clock A. M., after feeding grain and hay, but before watering.

#### FEEDS

The alfalfa hay used in this feeding test was purchased in the Valley at \$7.00 per ton, baled and delivered. The hay was all of first-class quality.

The wheat fed was raised on the Station farm, and for the experiment, was estimated at one cent per pound. The bran fed was purchased at a cost of \$1.15 per hundred pounds, delivered.

Salt was kept by the steers all of the time.

Lot I was fed alfalfa hay and about one-third of a full grain ration composed of a mixture of wheat and bran, in the proportion of three parts of wheat to one part of bran by weight. On February 10th cracked wheat was substituted for whole wheat.

Lot II was fed alfalfa hay alone.

Both lots received all of the alfalfa hay they would consume. Lot I was started on a small quantity of grain, which was gradually increased until the desired amount was given. They were receiving the full amount in 48 days after the feeding was begun.

#### THE FEEDING PERIOD

The feeding experiment began January 29, 1904, and continued for three months and 28 days, or 118 days, closing on May 26, 1904. The steers were all in good condition for the local market when sold.

## TABLES

Table I shows the amount of food consumed and the net profit on each lot with alfalfa hay reckoned at cost on the local market, at cost of production baled and stored, and at cost in the stack. In each instance we find Lot II, which received alfalfa hay alone, consumed more hay but gave a larger net profit than Lot I.

Table II shows the amount of food consumed by each lot, the average daily roughage per head, the average roughage per month, and the nutritive ratio of the rations fed. The table shows that there was very little difference in the lots as to the amount of feed eaten, but Lot II, fed on alfalfa only, required a little more roughage per day than did Lot I, which received the grain ration.

Table III shows the weights and gains per lot, per head, the average daily gains, the amount of food required to make one pound gain, and the cost of one pound gain.

Table IV shows the comparison between lots. From this table we see that Lot I, which received alfalfa hay, wheat, and bran, made a slightly larger average daily gain per head than did Lot II, which received only alfalfa hay. It also shows that the grain-fed lot required less roughage for a pound of gain than it did for the lot receiving alfalfa hay only; but the lot which received alfalfa hay only made nearly the same gain in weight and at a cost of 50 cents per hundred less than for the lot given a grain ration.

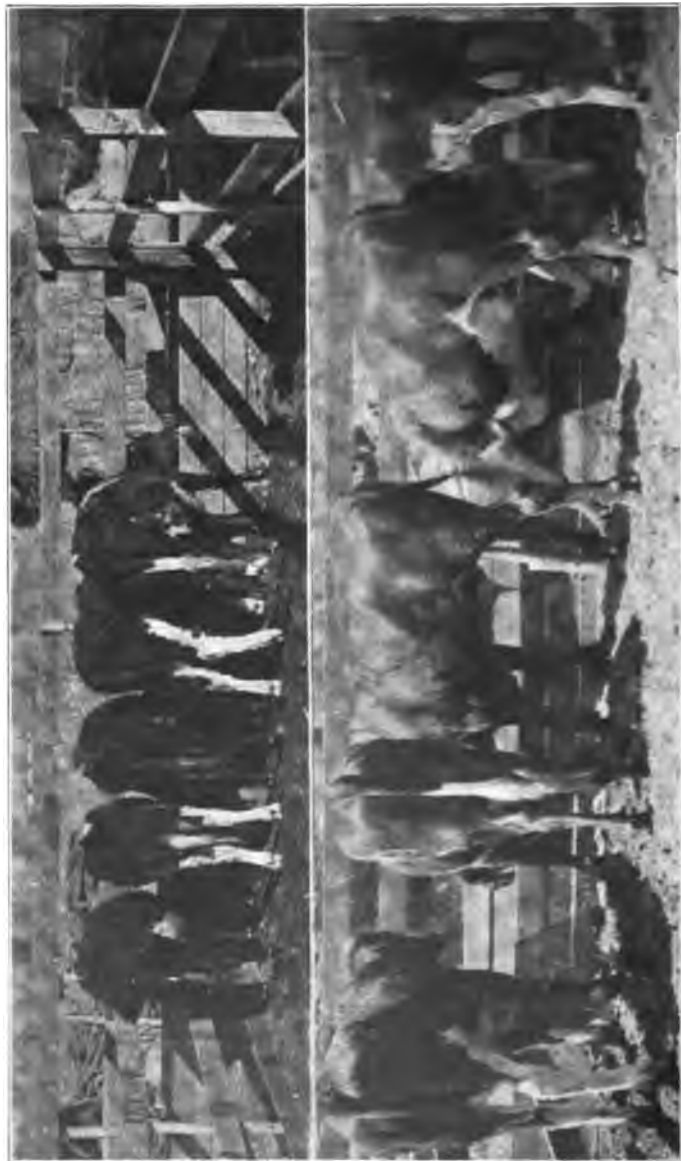
Table V shows the return per ton for the alfalfa hay fed each lot. Lot II gave a return of \$8.36 per ton for the alfalfa hay eaten, or 98 cents more per ton than did Lot I. This shows that the cheaper beef was produced by feeding alfalfa hay alone.

Table VI shows the weights and gains of each lot by periods of thirty days. These weights show that for the first month the gain for each lot was practically the same, but for the second and third months Lot I, which received the grain ration, made the larger gain; while for the fourth month Lot II, receiving alfalfa hay only, made the larger gain. Refer-





**PLATE I.**



The upper figure represents Lot I when grain feeding was begun.  
The lower figure represents Lot I at the end of the test.



**PLATE II.**



The upper figure represents Lot 2 at the beginning of the test.  
The lower figure represents Lot 2 at the end of the test.

ring to Table III it will be seen that the total gain was slightly in favor of Lot I, which received a grain ration in addition to the alfalfa hay.

Table VII shows that in each year's feeding test the lots receiving a grain ration consumed less roughage per day than did those receiving alfalfa hay only. If we take an average of the three years' feeding tests we find that the lots receiving a grain ration made a slightly larger daily gain per 1,000 pounds live weight than did the lots receiving alfalfa hay only. It required nearly one pound more food for a pound of gain for those receiving alfalfa hay only, than for the grain-fed lot. The cost of one pound of gain was higher when a grain ration was fed than when alfalfa was fed alone.

In noticing the return per ton for alfalfa hay we see that Lot II, fed during the winter of 1904-5, which received alfalfa hay only, gave a larger return per ton for the hay fed than did the grain-fed lot; while the opposite is true of the steers fed during 1902-3. In this test the lot receiving the wheat and bran ration gave the larger return per ton for the hay eaten.

Table VIII shows that the first day after dehorning the steers in both lots shrank quite heavily, but each day thereafter they gained in weight, with the exception of Lot I, which on the fourth day showed a shrinkage of 16 pounds, and Lot II on the seventh day showed a shrinkage of 8 pounds. These light shrinkages at times are probably due more to variation in weights from day to day than from the effects of dehorning.

Probably not all of the loss in weight was due to the effect of dehorning. In this connection, the fact that the steers were driven in from the range and immediately placed in small lots under entirely new surroundings and with a change of feeds, must not be overlooked.

We may account for a part of the rather heavy loss in weight in Lot II by the fact that one of the steers in this lot was very wild.

## STEER FEEDING

Table I.—Financial Statement

Showing the profit on each lot with alfalfa hay figured as follows: At the market price on board car, at cost on board car, and at cost in the stack on the farm.

|                                                    | Alfalfa Hay<br>Baled @ \$7.00<br>per Ton<br>Wheat @ \$20.00<br>per Ton<br>Wheat Bran @<br>\$23.00 per Ton<br>Dr. Cr. |           | Alfalfa Hay<br>Baled @ \$3.50<br>per Ton<br>Wheat @ \$20.00<br>per Ton<br>Wheat Bran @<br>\$23.00 per Ton<br>Dr. Cr. |           | Alfalfa Hay<br>in Stack @ \$2.50<br>per Ton<br>Wheat @ \$20.00<br>per Ton<br>Wheat Bran @<br>\$23.00 per Ton<br>Dr. Cr. |           |
|----------------------------------------------------|----------------------------------------------------------------------------------------------------------------------|-----------|----------------------------------------------------------------------------------------------------------------------|-----------|-------------------------------------------------------------------------------------------------------------------------|-----------|
| Lot 1                                              |                                                                                                                      |           |                                                                                                                      |           |                                                                                                                         |           |
| By 5 steers, 3886 pounds live<br>weight @ 3¼c..... | \$.....                                                                                                              | \$ 126.62 | \$.....                                                                                                              | \$ 126.62 | \$.....                                                                                                                 | \$ 126.62 |
| To 5 steers, 2800 pounds live<br>weight @ 2¾c..... | 77.00                                                                                                                | .....     | 77.00                                                                                                                | .....     | 77.00                                                                                                                   | .....     |
| To 9999 pounds alfalfa hay..                       | 35.00                                                                                                                | .....     | 17.50                                                                                                                | .....     | 12.50                                                                                                                   | .....     |
| To 919 pounds wheat.....                           | 9.19                                                                                                                 | .....     | 9.19                                                                                                                 | .....     | 9.19                                                                                                                    | .....     |
| To 306 pounds wheat bran....                       | 3.52                                                                                                                 | 124.71    | 3.52                                                                                                                 | 107.21    | 3.52                                                                                                                    | 102.21    |
| Profit.....                                        | 1.91                                                                                                                 |           | 19.41                                                                                                                |           | 24.41                                                                                                                   |           |
| Lot 2                                              |                                                                                                                      |           |                                                                                                                      |           |                                                                                                                         |           |
| By 5 steers, 3781 pounds live<br>weight @ 3¼c..... | .....                                                                                                                | 122.86    | .....                                                                                                                | 122.86    | .....                                                                                                                   | 122.86    |
| To 5 steers, 2758 pounds live<br>weight @ 2¾c..... | 75.85                                                                                                                | .....     | 75.85                                                                                                                | .....     | 75.85                                                                                                                   | .....     |
| To 11248 pounds alfalfa hay..                      | 39.37                                                                                                                | 115.22    | 19.68                                                                                                                | 95.53     | 14.06                                                                                                                   | 89.91     |
| Profit.....                                        | 7.66                                                                                                                 |           | 27.35                                                                                                                |           | 32.97                                                                                                                   |           |

# STEER FEEDING

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**Table II.—Feed Consumed**

|                                                     | Lot 1<br>Pounds | Lot 2<br>Pounds |
|-----------------------------------------------------|-----------------|-----------------|
| Total alfalfa fed.....                              | 9999            | 11248           |
| Total wheat fed.....                                | 919             | .....           |
| Total wheat bran fed.....                           | 306             | .....           |
| Total feed.....                                     | 11224           | 11248           |
| Average daily roughage per head (118 days) .....    | 16.9            | 19.0            |
| Average roughage per head per month (30 days) ..... | 508.4           | 571.9           |
| Nutritive ratio.....                                | 1:4.1           | 1:3.8           |

**Table III.—Weights and Gains**

|                                                     | Lot 1    | Lot 2    |
|-----------------------------------------------------|----------|----------|
| Weight at beginning at the test.....                | 2800     | 2758     |
| Weight at end of the test.....                      | 3896     | 3781     |
| Total gain.....                                     | 1096     | 1023     |
| Average gain per head.....                          | 219.2    | 204.6    |
| Average daily gain per head (118 days).....         | 1.86     | 1.73     |
| Average daily gain per 1000 pounds live weight..... | 3.31     | 3.14     |
| Pounds of food to make one pound gain.....          | 10.24    | 11.00    |
| Pounds of food to make 100 pounds gain.....         | 1024     | 1100     |
| Cost of one pound gain*.....                        | \$ .0435 | \$ .0385 |
| Cost of 100 pounds gain*.....                       | 4.35     | 3.85     |

\* Alfalfa hay at \$7.00 per ton.

## STEER FEEDING

Table IV.—Comparison

Comparison between Lot 1, fed on alfalfa hay and wheat and bran in the proportion of three parts wheat to one part bran, and Lot 2, fed on alfalfa hay alone.

|                                                                     | Lot 1                       | Lot 2             |
|---------------------------------------------------------------------|-----------------------------|-------------------|
|                                                                     | Alfalfa Hay, Wheat and Bran | Alfalfa Hay Alone |
| Total pounds gained.....                                            | 1096                        | 1023              |
| Average gain per head.....                                          | 219.2                       | 204.6             |
| Average daily gain per head (118 days).....                         | 1.86                        | 1.73              |
| Average daily gain per 1000 pounds live weight.....                 | 3.31                        | 3.14              |
| Pounds roughage to make 1 pound gain.....                           | 9.12                        | 11.00             |
| Pounds roughage to make 100 pounds gain.....                        | 912                         | 1100              |
| Cost of 100 pounds gain (alfalfa hay @ \$7.00 per ton).....         | 4.35                        | 3.85              |
| Cost of 100 pounds gain (alfalfa hay @ \$3.50 per ton).....         | 2.76                        | 1.92              |
| Cost of 100 pounds gain (alfalfa hay @ \$2.50 per ton).....         | 2.30                        | 1.57              |
| Return per ton for alfalfa hay.....                                 | 7.33                        | 8.36              |
| Return per acre for alfalfa hay*.....                               | 22.14                       | 25.08             |
| Costs of steers per head, average (2½¢ per pound, live weight)..... | 15.40                       | 15.17             |
| Selling price per head, average (3¼¢ per pound, live weight)...     | 25.32                       | 24.58             |
| Cost of food per head, average, (alfalfa @ \$7.00 per ton).....     | 9.54                        | 7.87              |
| Profit per head, average (alfalfa hay @ \$7.00 per ton).....        | .38                         | 1.53              |
| Cost of food per head, average (alfalfa hay @ \$3.50 per ton)....   | 6.04                        | 3.94              |
| Profit per head, average (alfalfa hay @ \$3.50 per ton).....        | 3.88                        | 5.47              |
| Cost of food per head, average (alfalfa hay @ \$2.50 per ton)...    | 5.04                        | 2.81              |
| Profit per head, average (alfalfa hay @ \$2.50 per ton).....        | 4.68                        | 6.59              |

\* Alfalfa hay reckoned at an average yield of three tons per acre per year.



Table V.—Return Per Ton for Alfalfa Hay

| Lot 1                                                        |          |           |
|--------------------------------------------------------------|----------|-----------|
| By 5 steers, 3896 pounds live weight @ $3\frac{1}{4}$ c..... | .....    | \$ 126.62 |
| To 5 steers, 2800 pounds live weight @ $2\frac{1}{4}$ c..... | \$ 77.00 | .....     |
| To 919 pounds wheat @ \$20.00 per ton.....                   | 9.19     | .....     |
| To 306 pounds wheat bran @ \$23.00 per ton.....              | 3.52     | 89.71     |
| Balance to the credit of alfalfa hay.....                    | .....    | 36.91     |
| Received for alfalfa hay, per ton.....                       | .....    | 7.38      |

| Lot 2                                                        |       |        |
|--------------------------------------------------------------|-------|--------|
| By 5 steers, 3781 pounds live weight @ $3\frac{1}{4}$ c..... | ..... | 122.86 |
| To 5 steers, 2758 pounds live weight @ $2\frac{1}{4}$ c..... | 75.85 | 75.85  |
| Balance to the credit of alfalfa hay.....                    | ..... | 47.03  |
| Received for alfalfa hay, per ton.....                       | ..... | 8.36   |

Table VI.—Weights and Gains by Periods of Thirty Days

| Dates of Weighings          | No. of Days Fed | Lot 1         |             | Lot 2         |             |
|-----------------------------|-----------------|---------------|-------------|---------------|-------------|
|                             |                 | Weight Pounds | Gain Pounds | Weight Pounds | Gain Pounds |
| January 29-30-31.....       | 00              | 2800          | .....       | 2758          | .....       |
| February 28-29—March 1..... | 30              | 3134          | 334         | 3002.6        | 334.6       |
| March 29-30-31.....         | 60              | 3469.3        | 335.3       | 3374          | 281.4       |
| April 27-28-29.....         | 89              | 3781.6        | 292.3       | 3600          | 226         |
| May 24-25-26.....           | 118             | 3896          | 134.4       | 3781.3        | 191.3       |

Note—The steers were weighed three consecutive days and averages of these weights are given.

## STEER FEEDING

Table VII.—Comparison of Three Years' Results on Steer Feeding

|                                                              | 1904-5                      |             |  | 1905-6                              |                                     |                                               |             | 1901-2      |                                     |                                     |
|--------------------------------------------------------------|-----------------------------|-------------|--|-------------------------------------|-------------------------------------|-----------------------------------------------|-------------|-------------|-------------------------------------|-------------------------------------|
|                                                              | Lot 1                       | Lot 2       |  | Lot 1                               | Lot 2                               | Lot 3                                         | Lot 4       | Lot 1       | Lot 2                               | Lot 3                               |
|                                                              | Alfalfa Hay, Wheat and Bran | Alfalfa Hay |  | Alfalfa Hay and a Light Corn Ration | Alfalfa Hay and a Heavy Corn Ration | Alfalfa Hay and a Light Bran and Wheat Ration | Alfalfa Hay | Alfalfa Hay | Alfalfa Hay and a Light Corn Stover | Alfalfa Hay and a Light Corn Stover |
| Average daily roughage per head, pounds.....                 | 16.9                        | 19.00       |  | 18.61                               | 18.15                               | 18.44                                         | 19.21       | 24.28       | 22.69                               | 20.87                               |
| Average roughage per head per month, pounds.....             | 508.4                       | 571.9       |  | 558.3                               | 544.5                               | 553.2                                         | 576.3       | 728.5       | 680.9                               | 626.3                               |
| Average daily grain per head, pounds.....                    | 2.07                        |             |  | 1.18                                | 1.60                                | 1.13                                          |             |             |                                     |                                     |
| Average grain per head per month, pounds.....                | 62.1                        |             |  | 36.4                                | 50.7                                | 33.9                                          |             |             |                                     |                                     |
| Net gain per head, pounds.....                               | 219.2                       | 201.6       |  | 136.                                | 178.                                | 179.                                          | 173.5       | 261.6       | 286.                                | 323.5                               |
| Average daily gain per head, pounds.....                     | 1.86                        | 1.73        |  | 1.22                                | 1.60                                | 1.62                                          | 1.56        | 1.96        | 1.49                                | 1.16                                |
| Average daily gain per 1,000 pounds live weight, pounds..... | 3.31                        | 3.14        |  | 2.186                               | 2.940                               | 2.981                                         | 2.933       | 2.13        | 2.30                                | 1.82                                |
| Pounds food required to make 1 pound gain.....               | 10.24                       | 11.00       |  | 16.27                               | 12.38                               | 12.69                                         | 12.29       | 17.82       | 15.23                               | 17.93                               |
| Pounds roughage required to make 1 pound gain.....           | 9.12                        | 11.00       |  | 15.30                               | 11.31                               | 11.39                                         | 12.29       | 17.82       | 15.23                               | 17.93                               |
| Cost of 1 pound gain.....                                    | \$ .0335                    | \$ .0385    |  | \$ .066                             | \$ .063                             | \$ .047                                       | \$ .043     | \$ .0624    | \$ .0518                            | \$ .0617                            |
| Return per ton for alfalfa hay*                              | 7.88                        | 8.36        |  | 6.83                                | 7.81                                | 8.59                                          | 8.44        | 10.71       | 12.81                               | 11.86                               |

\*Return per ton for Alfalfa hay after all other feeds are paid for.

**Table VIII. —Effect of Dehorning**

Showing the date of weighing, weights, and the daily gain or loss.

| Date of Weighing                     | Lot 1          |                       | Lot 2          |                         |
|--------------------------------------|----------------|-----------------------|----------------|-------------------------|
|                                      | Weight<br>lbs. | Gain or<br>Loss<br>a. | Weight<br>lbs. | Gain or<br>Loss<br>lbs. |
| January 29.....                      | 2840           | 00                    | 2830           | 00                      |
| January 30.....                      | 2768           | -72                   | 2710           | -120                    |
| January 31.....                      | 2792           | 24                    | 2734           | 24                      |
| February 1.....                      | 2856           | 64                    | 2784           | 50                      |
| February 2.....                      | 2840           | -16                   | 2800           | 16                      |
| February 3.....                      | 2884           | 44                    | 2824           | 24                      |
| February 4.....                      | 2880           | -4                    | 2816           | -8                      |
| Total gain or loss in seven days.... | .....          | 40                    | .....          | -14                     |

Note—The steers were weighed in the morning of January 29 and dehorned immediately. They were weighed daily thereafter for six days.



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**APRIL 1906**

**New Mexico College of Agriculture and Mechanic Arts**

**AGRICULTURAL EXPERIMENT STATION**

**AGRICULTURAL COLLEGE, N. M.**



**PURPLE DAMASCUS,**  
A Promising Mid-Season Variety.

**EUROPEAN GRAPES**

**BY**  
**FABIÁN GARCÍA.**

**SANTA FE, N. M.:**  
**THE NEW MEXICAN PRINTING COMPANY.**  
1906.

# NEW MEXICO AGRICULTURAL EXPERIMENT STATION

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## EUROPEAN GRAPES

### Introduction

The Rio Grande Valley from Bernalillo on the north to the Texas line on the south seems to be well adapted to grape-growing. Old vineyards are found in most of the agricultural districts along the Valley. Most of these vineyards are owned and attended to by our Mexican vineyardists who, on the whole, are successful in this branch of fruit-growing. The vineyards, which are principally Mission and Muscat of Alexandria varieties (*Vitis vinifera*), are comparatively small; but large enough to demonstrate the adaptability of certain varieties of, if not all, the European or so-called "California" grapes. While the native or American grapes grow quite well in the Valley, they do not seem to be so satisfactory for commercial purposes, and are grown only in a limited way for home use. The European grape has been cultivated many years in the Rio Grande Valley, and is one of the best fruits grown in this section; in former years it was the most profitable one. The exact time of the appearance of the European grapes in the different sections of the Rio Grande Valley is difficult to ascertain. However, in the Mesilla Valley, where grape-growing has been carried on quite extensively, the date of the planting of the first vineyards is probably shortly after 1841; for about that date Doña Ana, the oldest town in the Valley, was settled.

The Mission, or "El Paso" grape, appears to have been the first variety planted, and the origin of it seems to be more or less in doubt. Old grape-growers in the Valley differ as to whether it came from cuttings brought over from Spain into Mexico, or whether it is a seedling from seeds of raisins. Whatever the origin, it is quite probable that the Mission grape was introduced into the Territory from Mexico.

In this connection, in 1867 Judge J. G. Knapp, a resident



of Mesilla in the early sixties, writes of the grapes along the Rio Grande, in the following terms:

"Two kinds of grapes are grown—the El Paso\* and Muscatel. The origin of these grapes is shrouded in mystery. No trace can be found of them beyond the vineyards of El Paso,† though they evidently are of Asiatic origin, and probably were produced from seeds of dried grapes from Spain, or even further East, planted by some of the Spanish missionaries.§"

The Muscatel grape referred to above is a small, sweet, pale yellow—almost white—grape; it has a muscat flavor, and it is earlier than the Mission. This grape has practically gone out of cultivation, while the Mission is still extensively grown.

The varieties found in the commercial vineyards in the Rio Grande Valley are the Mission and Muscat of Alexandria. The Mission is the more popular and possesses some excellent qualities.

The shipping season in the Mesilla Valley begins about the 15th of August and lasts until the Mission grapes are gone, which is about the last of September. The present commercial varieties are all mid-season grapes, a fact which shortens the shipping period. If earlier and later ripening varieties were grown, the shipping season would be extended considerably. With this need in view, the Experiment Station has been conducting the variety test of *vinifera* grapes herein reported.

---

\*More commonly known at present as the Mission.

†Meaning Ciudad Juárez, a town in Mexico across the river opposite the present El Paso, which is in Texas.

§Wisconsin Union, Saturday, March 23, 1867.

### STATION TEST

In the spring of 1900 the experimental vineyard of 1.17 acres was planted to 52 varieties. Most of the varieties, or 67.8 per cent., were bought from the Fancher Creek Nurseries, Fresno, California. These vines were one year old rooted plants, and there were from two to forty plants of each variety. The Mission, Muscat of Alexandria, and one of the Madre Field Comet were started from cuttings taken from some of the vineyards in this locality. The cuttings were planted in the spring in their permanent places, and practically all rooted and made a good growth the first season. The remaining varieties, 26.9 per cent.—of which there was but one vine of each—were sent from the United States Department of Agriculture.

The vines, which were set out during the first and second weeks in March, were planted eight feet apart in the row and with twelve feet between the rows. This latter distance of twelve feet is too far apart. All the vines that started made a good growth the first season. A few plants of the varieties from California, however, failed to grow. This seems to have been due to the poor condition of those plants at the time of setting them out; for they were shipped by freight and owing to delay on the way were received in poor condition. Some of the plants were so badly dried out that they were permanently injured. In the following year—1901— the vacancies were planted to vines secured from the same place.

During the test this experimental vineyard received very simple treatment. This consisted of a plowing in the early spring followed by three to four shallow cultivations during the growing season, three to four hoeings in the rows to keep the weeds down, and from four to six irrigations. The treatment during the dormant period consisted of hilling up the vines in the late fall, one winter irrigation, if the winter was too dry, unhilling and pruning in the spring. With the exception of some Thompson's Seedless vines, which were trellised, the stump method of pruning was practiced throughout.

The soil in the vineyard varies from a medium loam to a heavy adobe. It has been noticed during the test that the vines growing in the lighter soil invariably produced better growth, as well as more and larger grapes, than on the adobe soil. It has also been noticed that there was a tendency towards an earlier ripening of the berries on the lighter soil.

Most of the vines planted in the spring of 1900 ripened their first crop in 1902. During the following year the crop was larger. In 1904 the crop was practically a failure, and therefore no notes were recorded. The spring 1904 was very unfavorable. The earlier part of the spring was unusually warm, and this started vegetation growing early. About the first of the second week in April there was a marked change in the weather conditions, and on April 16th and 17th freezes occurred which injured all the new growth on the vines at the Station. Many of these vines had made a growth of twelve inches. After these freezes the outlook for a grape crop was very discouraging. Since the grape canes had been pruned back to one or two eyes, and these had practically all sprouted, there were no more buds left on the previous year's growth. The subsequent growth, which came after some delay, was mostly from adventitious buds on the old wood below the previous year's growth. The main stump of some of the vines seemed to have been injured by the freezing, as a few of them died down to the ground. The freezes occurred unusually late, and were quite local. Vineyards toward the middle of the valley were just barely touched, while others escaped entirely. Those located along the foothills suffered the most. According to the statement of old residents in the valley, it had been a great many years since grapes were injured by frost as much as they were in the spring of 1904.

The season of 1905 was more favorable. The vines made a good growth, and produced an average crop of grapes. The variety test closed with the season's work. The following is an itemized statement of the cost of each operation on the 1.17 acre vineyard during the season of 1905:

## EUROPEAN GRAPES

|                                                                                               |          |
|-----------------------------------------------------------------------------------------------|----------|
| March 16th, plowing middles and as much dirt away from the vine as possible, 10 hrs. at 7½c,* | .75      |
| March 25th, uncovering, 20 hrs. at 7½c,                                                       | 1.50     |
| March, 30th to April 5th, trimming, 38 hrs. at 11c,                                           | 4.18     |
| April 10th, bordering for irrigation, 2 hrs. at 11c*,                                         | .22      |
| April 18th, irrigation, well water, 2 hrs. 10 min., ‡                                         | 1.54     |
| April 28th, hoed in rows, 6 hours at 7½c,                                                     | .45      |
| May 8th, cultivating, 3 hrs. at 11c,*                                                         | .33      |
| May 28th, cultivating, 3 hrs. at 11c.*                                                        | .33      |
| May 30th-31st, hoeing, 13 hrs. at 7½c,                                                        | .97      |
| June 3rd, irrigation, well water, 1 hr. 40 min., ‡                                            | 1.07     |
| June 12th, cultivating, 3 hrs. at 11c, *                                                      | .33      |
| June 19th, partial hoeing, 1 hr., at 7½c,                                                     | .075     |
| June 28th, irrigation, well water. 1 hr. 30 min., ‡                                           | .99      |
| July 20th, irrigation, well water, 1 hr. 30 min., ‡                                           | .85      |
| August 4th-5th, hoeing, 40 hrs. at 7½c,                                                       | 3.00     |
| August 4th-5th, cultivating. 2 hrs. at 11c. *                                                 | .22      |
| Total cost,                                                                                   | \$16.805 |
| Per acre,                                                                                     | 14.355   |

## DESCRIPTION OF VARIETIES TESTED

These varieties are divided into three groups in reference to their ripening season—early, mid-season, and late—and in each group they follow in an alphabetical order.

## Early Varieties

1. **Cannonhall Muscat** (*Source, California*)

Vine vigorous, medium to large canes. Bunches large and loose; berries very large, slightly oval, greenish yellow, firm, rich; muscat flavor. A fair early variety, except that it tends to be sterile. First grapes picked August 4, 1903; August 3, 1905.

2. **Chasselas Ciotat** (*Source, California*)

Vine small and slender grower, prolific; leaves very much lacinated, looking much like parsley leaves and often called Parsley-leaved grapes. Bunches small to medium, compact; berries small to medium, greenish yellow, soft, covered with a pale bloom; juicy and pleasant. Not a desirable early grape.

‡ The irrigation was carried on in co-operation with the Agricultural Department. The water was all pumped from the Agricultural Department well. Engineer's wages, cost of coal and cost of applying water are included in the amount for each irrigation.

\* Team and machinery not included in the cost.

First grapes picked August 2, 1902; August 7, 1903; August 10, 1905.

3. **Chasselas Croquant** (*Source, California*)

Vine large and vigorous grower, prolific. Bunches large and compact; berries large, roundish oval, moderately firm, greenish-yellow, sweet. Bunches and berries are larger than in the other Chasselas grapes mentioned. A fair early grape. First grapes picked August 4, 1903; August 3, 1905.

4. **Chasselas de Florence** (*Source, California*)

Vine small, prolific, very slender and short canes. Bunches small to medium, compact, slightly tapering and slightly shouldered; berries small to medium, round, greenish yellow, transparent, covered with a light whitish bloom, not firm, juicy, sweet with a tendency toward insipidness. A poor early variety. First grapes picked July 29, 1902; August 2, 1903; August 2, 1905.

5. **Chasselas de Fontainbleau** (*Source, California*)

Vine small to medium grower, prolific, slender and short canes. Bunches medium to large, slightly tapering, very compact; some tend to shoulder; berries medium to large, round, greenish yellow, almost transparent, covered with a light pale bloom, moderately firm, juicy, sweet. A fair early variety. First grapes picked July 29, 1902; August 3, 1903; August 3, 1905.

6. **Chasselas de Fontainbleau** (*Source, U. S. D. A.*)

Identical with the above Chasselas de Fontainbleau.

7. **Chasselas Napoleon** (*Source, California*)

Vine strong grower, with slender, short jointed canes. Bunches medium, moderately loose, long and tapering; berries medium, round, greenish yellow, with a slight red tinge, covered by a pale bloom; only moderately firm, juicy and sweet. Not as promising an early grape as the Chasselas de Fontainbleau. First grapes picked July 31, 1902; August 5, 1903; August 5, 1905.

8. **Chasselas Rose** (*Source, California*)

Vine medium to strong grower, moderately prolific; slender canes. Bunches medium, compact, slightly tapering

and shouldered; berries medium to large, round, clear rose, covered with a pale bloom, slightly transparent, moderately firm, juicy, sweet. A fair early variety. First grapes picked July 30, 1902; August 4, 1903; August 3, 1905.

9. **Chasselas Vibert** (*Source, California*)

Vine medium grower. Bunches small to medium, compact; berries medium, round, moderately firm, juicy, sweet. On the whole not a desirable early variety. First grapes picked August 6, 1903.

10. **Early Madeleine** (*Source, California*)

Vine medium grower, tends to bend over and trail, prolific. Bunches large, compact; berries large, oval, greenish yellow, quite firm, very juicy, sweet. A fair early variety. First grapes picked August 7, 1902; August 4, 1903; August 3, 1905.

11. **Muscat Proceco Du Puy de Dome** (*Source, California*)

Vine vigorous and prolific, slender and moderately long jointed canes. Bunches medium to large, slightly tapering, very compact and shouldered; berries medium, round, reddish purple, firm, covered with a light bluish bloom, juicy, has a decided muscat flavor. A fair early grape. First grapes picked July 29, 1902; August 4, 1903; August 3, 1905.

12. **Napoleon Muscadine** (*Source, U. S. D. A.*)

Vine small to medium grower, fair bearer. Bunches medium, compact; berries medium round, firm, yellowish green, juicy, sweet. Has no special value. First grapes picked August 1, 1902; August 3, 1903; August 3, 1905.

13. **Thompson's Seedless** (*Source, California*)

Vine very strong and large grower, prolific. Bunches very large, compact, long and tapering (some measure 15 inches), shouldered; berries small to medium, oval, pale yellow, transparent, firm, pleasant and sweet; seedless. A promising early variety. First grapes picked July 31, 1902; August 4, 1903; August 5, 1905.

14. **Sultana** (*Source, California*)

Vine strong grower, somewhat slender canes, prolific. Bunches large, compact, somewhat shouldered; berries small, round to oblong, pale yellow inclined to amber, juicy, sweet;

seedless. Not as good an early variety as Thompson's Seedless. First grapes picked August 2, 1902; August 5, 1903; August 8, 1905.

15. **White Corinth** (*Source, California*)

Vine strong and large grower; shy bearer. Bunches medium, very compact, shouldered; berries very small, roundish oval, very juicy, slightly acid, greenish yellow, soft, covered with a pale bloom, seedless. A poor variety. First grapes picked July 29, 1902; August 2, 1903; August 1, 1905.

16. **White Sweet Water** (*Source, California*)

Identical with Chasselas de Fontainebleau.

### Mild-Season Varieties

17. **Black Hamburg** (*Source, California*)

Vine vigorous and moderately long grower, prolific. Bunches large, compact; berries large, oblong oval, black, firm, sweet. A good medium variety. First grapes picked August 8, 1903; August 10, 1905.

18. **Black Hamburg** (*Source, U. S. D. A.*)

Vine medium grower, good bearer. Bunches large, somewhat tapering, compact, berries medium large, roundish to oval, firm, sweet. Fair variety. First grapes picked August 8, 1903; August 10, 1905.

19. **Black Malvoise** (*Source, California*)

Vine vigorous, slender canes, prolific. Bunches medium, compact; berries medium, oblong oval, black, covered with a light pale bloom, firm, sweet, juicy, pleasant. Promising wine grape. First grapes picked August 12, 1902; August 16, 1903. No ripening data for 1905.

20. **Black Prince** (*Source, California*)

Vine medium grower, fair yielder. Bunches large, compact; berries large, round, firm, black, covered with a bloom, sweet and rich. Fair. The vines in the test have practically been killed by the grape crown-gall. First grapes picked August 22, 1903; August 26, 1905.

21. **Black St. Peter** (*Source, U. S. D. A.*)

Vine strong grower, slender canes, good bearer. Bunches

medium to large, compact, tapering; berries large, round to oblong, dark purple to black, covered with a pale bloom, not firm, juicy, pleasant. It has no particular merit. First grapes picked August 12, 1902; August 18, 1903; August 15, 1905.

22. **Blue Spanish** (*Source, California*)

Vine strong and large grower, prolific. Bunches large, somewhat loose; berries large, roundish oblong, dark blue, covered with heavy bloom, soft, sweet, attractive. Good for home use. First grapes picked August 10, 1902; August 13, 1903; August 12, 1905.

23. **Burger** (*Source, California*)

Vine medium grower. Bunches medium to large, compact; berries medium, yellowish green, round, juicy. Wine grape. First grapes picked August 15, 1905.

24. **Champion Hamburg** (*Source, U. S. D. A.*)

Vine medium grower, medium bearer. Bunches medium, loose; berries medium to large, roundish oval, black, not firm, juicy and sweet. Resembles Black Hamburg. Fair. First grapes picked August 10, 1902; August 10, 1903; August 13, 1905.

25. **Chas. Worth Tokay** (*Source, U. S. D. A.*)

Vine medium grower. Bunches small and loose; berries medium, round, firm, greenish yellow, sweet. Has no special value. First grapes picked August 12, 1903; August 10, 1905.

26. **Fehér Zagos** (*Source, California*)

Vine vigorous grower, heavy bearer. Bunches large and compact; berries medium to large, oblong oval, yellowish green, firm, sweet, juicy. Wine grape. First grapes picked August 20, 1903; August 15, 1905.

27. **Hausco** (*Source, California*)

Vine medium, moderately short canes, grows much like the Muscat of Alexandria. Bunches large, loose; berries large, oval, yellowish green, firm, juicy, sweet. Resembles the Muscat of Alexandria in many respects. First grapes picked August 16, 1902; August 16, 1903; August 12, 1905.



28. **Jura Muscat** (*Source, California*)

Vine medium grower, light bearer. Bunches medium, long, tapering, compact; berries small to medium, round to oval, coppery red, covered with a pale bloom, moderately firm, juicy, sweet. Has no special value. First grapes picked August 12, 1903; August 15, 1905.

29. **Madre Field Comet** (*Source, N. M. Experiment Station*)

Vine strong grower, prolific. Bunches very large and compact; berries very large, round, black, covered with a pale bloom, not firm, juicy, sweet; ripen irregularly. Too soft for shipping; better for home use. First grapes picked August 18, 1902; August 18, 1903; August 15, 1905.

30. **Madre Field Comet** (*Source, U. S. D. A.*)

Identical with the above.

31. **Mission or "El Paso"** (*Source, Mesilla, N. Mex.*)

Vine vigorous grower, very prolific, well adapted to the stump system of pruning. Bunches large, loose, tapering, with a tendency to taper too much; berries medium to large, round, black, covered with a light bloom, moderately firm, juicy, very sweet and pleasant. Extensively grown for commercial purposes in the Mesilla Valley. First grapes picked August 20, 1902; August 18, 1903; August 17, 1905.

32. **Mitchell's Hamburg** (*Source, U. S. D. A.*)

Vine medium grower. Bunches medium, and moderately loose; berries large, oval, black, pleasant. Has no special value. First grapes picked August 10, 1903; August 13, 1905.

33. **Muscat of Alexandria** (*Source, Mesilla, N. Mex.*)

Vine good grower, canes moderately short jointed, heavy bearer. Bunches large, tapering, loose; berries large, roundish to oval, yellowish green, covered with a light bloom, firm, sweet, rich. Ships well. Extensively grown for commercial purposes in the Mesilla Valley. First grapes picked August 10, 1902; August 12, 1903; August 10, 1905.

34. **Muscat Rose** (*Source, California*)

Vine medium grower, not prolific. Bunches small, compact; berries small, round with a slight tendency to oblong, yellowish to violet, not firm, juicy, sweet, large seeds. On the

whole a poor variety. First grapes picked August 10, 1903; August 12, 1905.

**35. Pope's Hamburg** (*Source, U. S. D. A.*)

Vine small grower. Bunches small and loose; berries medium roundish-oval, black, not firm, very sweet and juicy. Fair. First grapes picked August 9, 1902; August 15, 1903; August 12, 1905.

**36. Prinia Vis Frontigean** (*Source, U. S. D. A.*)

Vine medium grower, stout canes. Bunches small to medium, fairly compact and tapering; berries medium, round, greenish yellow, covered with a light pale bloom, moderately firm, juicy, pleasant; has a muscat flavor. Not especially promising. First grapes picked August 8, 1902; August 6, 1903; August 7, 1905.

**37. Purple Damascus** (*Source, California*)

Vine medium to large grower, heavy bearer. Bunches very large, compact; berries very large, dark purple to black, very firm, oblong to oval, covered with a pale bloom, sweet, good. Very promising for a shipping medium late variety. First grapes picked August 22, 1902; August 24, 1903; August 24, 1905.

**38. Rose of Peru** (*Source, California*)

Vine strong grower, more or less shy bearer. Bunches medium, loose; berries medium, round, very firm, sweet, red to black, pleasant, promising. Vines in the test badly affected by the crown-gall. First grapes picked August 17, 1902; August 20, 1903; August 15, 1905.

**39. Sabal Kanski** (*Source, California*)

Vine vigorous grower, heavy bearer. Bunches very large and compact, attractive; berries very large, long oval, firm, juicy, coppery red, sweet. The fruit is subject to a rot. The berries begin to decay as soon as they start to color, and it is impossible to pick a perfect bunch. For this reason the variety is undesirable for planting here. First grapes picked, August 25, 1902; August 24, 1903; August 27, 1905.

**40. Trousseau** (*Source, California*)

Vine small to medium, heavy bearer. Bunches small to

medium, very compact; berries small, round, moderately firm, juicy, sweet, rich. This is a wine grape. First grapes picked August 12, 1903; August 10, 1905.

41. **Vennis Black Muscat** (*Source, U. S. D. A.*)

Vine strong grower, light bearer. Bunches medium, loose; berries medium, oblong oval, firm, black, juicy, sweet. Fair variety. First grapes picked August 11, 1902; August 17, 1903; August 13, 1905.

42. **Verdel** (*Source, California*)

Vine medium grower and slender canes, not a heavy bearer. Bunches small, loose; berries small, yellowish green, juicy, sweet. Only moderately fair. First grapes picked August 20, 1902; August 18, 1903; August 15, 1905.

43. **Welcome** (*Source, U. S. D. A.*)

Vine strong grower, fair bearer. Bunches medium, loose; berries medium to large, round, firm, black, fairly sweet. Has no special value. First grapes picked August 12, 1902; August 15, 1903; August 12, 1905.

44. **White Frontigau** (*Source, U. S. D. A.*)

Vine medium grower, fair bearer. Bunches medium, long and compact; berries medium, round, yellowish green, juicy, sweet; with a muscat flavor. Has no special value. First grapes picked August 10, 1902; August 11, 1903; August 12, 1905.

45. **Willinot's Hamburg** (*Source, U. S. D. A.*)

Vine strong grower and good bearer. Bunches large, shouldered, compact; berries medium to large, slightly oval, black, firm, juicy. Fair. First grapes picked August 15, 1903; August 13, 1905.

#### Late Varieties

46. **Black Morocco** (*Source, California*)

Vine vigorous, not adapted to the stump system of pruning, the canes bend down and tend to trail, prolific, with a decided tendency to continue to bear throughout the season; frequently there are three crops, the bunches of these late crops being small and inferior. Bunches large, loose; ber-

ries large, roundish, slightly tapering at one end, black, late, firm, juicy, ripen irregularly on bunches. On account of this irregular ripening of the berries on the bunch and the bad habit of producing two or three crops, it is not a good variety. First grapes picked October 1, 1902; September 30, 1903; September 30, 1905.

47. **Cornichon Black** (*Source, California*)

Vine strong grower, prolific. Bunches large, long, and loose, attractive; berries large, oval, tapering at both ends, firm, black, covered with a light pale bloom, juicy, sweet, good. A very promising late shipping grape. First grapes picked September 6, 1902; September 10, 1903; September 8, 1905.

48. **Black Portugal** (*Source, California*)

Vine medium grower, fair bearer. Bunches medium; berries medium, oblong to oval, black, covered with a pale bloom, firm, late, juicy. Has no special value. First grapes picked September 12, 1902; September 15, 1903; September 20, 1905.

49. **Emperor** (*Source, California*)

Vine medium grower, not well adapted to the stump system of pruning, as it does not form a good stump, heavy bearer. Bunches large, attractive; berries large, oblong, rich, rose color, very firm. A promising late shipping grape. First grapes picked September 18, 1903; September 15, 1905.

50. **Flame Tokay** (*Source, California*)

Vine strong grower, with stout reddish canes, heavy bearer. Bunches very large, moderately compact, shouldered, very attractive; berries large, oval, very firm, coppery red, covered with a pale bloom. A fine late shipping grape. This is one of the grapes shipped extensively from California to the Eastern markets. First grapes picked September 5, 1902; September 10, 1903; September 8, 1905.

51. **Gros Coleman** (*Source, California*)

Vine strong grower, well adapted to the stump system of pruning, heavy bearer; leaves large and heavily pubescent on the under surface. Bunches very large, compact, attractive; berries very large, round, firm, black, covered with a light

bluish bloom. A good late shipping grape. First grapes picked September 4, 1902; September 8, 1903; September 5, 1905.

**52. Malaga** (*Source, California*)

Vine strong grower, heavy bearer. Bunches very large, long, shouldered, and moderately loose; berries large, oblong to oval, firm, yellowish green, sweet. A good late shipping grape. First grapes picked August 25, 1902; August 25, 1903; August 28, 1905.

**Varieties Grown at the Experiment Station**

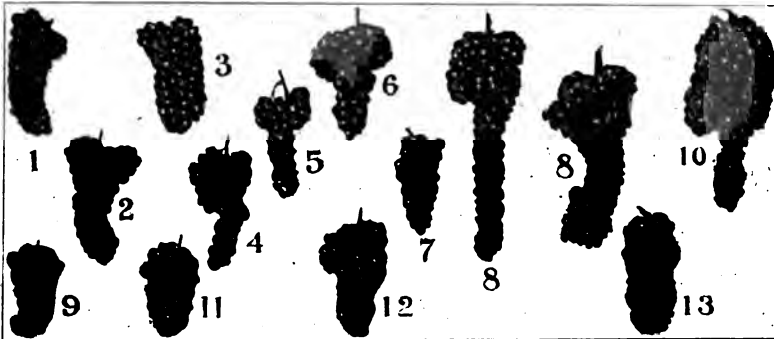


Fig. 1. 1. White Sweet Water. 2. Muscat Proceco Du Puy de Dome. 3. Early Madeleine. 4. Chasselas Ciotat. 5. White Corinth. 6. Blue Spanish. 7. Chasselas Napoleon. 8. Thompson's Seedless. 9. Chasselas de Florence. 10. Sultana. 11. Chasselas Rose. 12. Chasselas de Fontainbleau. 13. Chasselas Croquant.

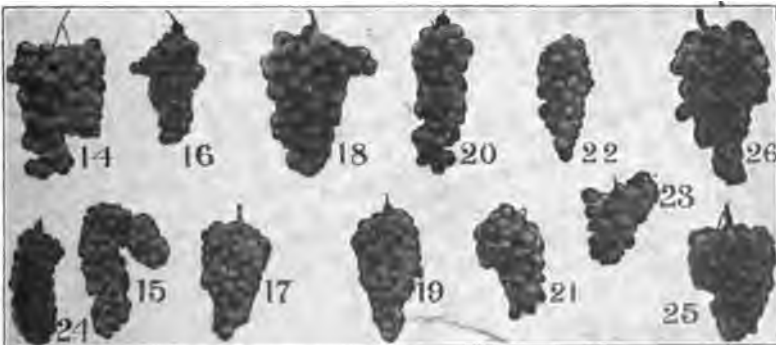


Fig. 2. 14. Gros Coleman. 15. Black St. Peters. 16. Zinfandel. 17. Black Hamburg. (Source, U. S. D. A.) 18. Purple Damascus. 19. Black Hamburg (Source, California). 20. Madre Field Comet. 21. Blue Spanish. 22. Black Malvoise. 23. Pierce. 24. Trousseau. 25. Wilder. 26. Mission.

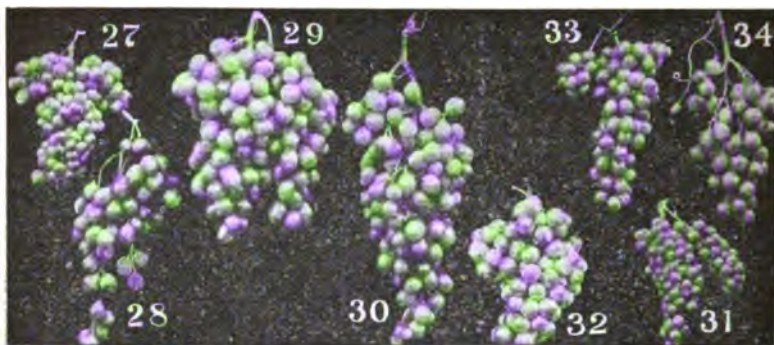


Fig. 3. 27. Gent Della Marmose (Source, U. S. D. A.) 28 Hausco. 29. Sabal Kanski 30. Malaga. 31. Smyrna (Source, U. S. D. A.). 32. Golden Champion. 33. Feher Zagos. 34. Muscat of Alexandria.

### SATISFACTORY VARIETIES

In the discussion of these varieties it has seemed advisable to group together those kinds considered satisfactory for the different purposes.

#### **Group I—Satisfactory Early Varieties:**

Chasselas de Fontainbleau, Chasselas Rose, Chasselas Croquant, Thompson's Seedless, Muscat Proceco Du Puy de Dome, Early Madeleine, and Cannonhall Muscat.

#### **Group II—Satisfactory Mid-Season Varieties:**

Black Hamburg, Blue Spanish, Muscat of Alexandria, Hausco, Mission, Purple Damascus, and Rose of Peru.

#### **Group III—Satisfactory Late Varieties:**

Malaga, Gros Coleman, Black Cornichon, Emperor, and Flame Tokay.

The rest of the varieties in the test are not considered so satisfactory as those named in the above groups.

#### **Group IV—Satisfactory for Home Vineyards:**

**Early:**—Chasselas de Fontainbleau, or Chasselas Rose, Thompson's Seedless, Early Madeleine, and Chasselas Croquant.

**Medium:**—Black Hamburg, Muscat of Alexandria, and Mission.

**Late:**—Malaga, Black Cornichon, and Flame Tokay.

**Group V**—Suitable for Commercial Plantations:

**Early:**—Chasselas de Fontainbleau, Thompson's Seedless, and Early Madeleine.

**Medium:**—Black Hamburg, Muscat of Alexandria, Mission, and Purple Damascus.

**Late:**—Black Cornichon, Emperor, Flame Tokay, and Gros Coleman.

**Group VI**—Eight Very Satisfactory Varieties:

Chasselas de Fontainbleau, Thompson's Seedless, Muscat of Alexandria, Mission, Purple Damascus, Emperor, Black Cornichon, and Flame Tokay.

#### **Observation On The Crown Gall**

The experimental vineyard was dug up and the vines removed during February, 1906 and a number of the varieties were examined for the crown-gall with the following results:

Table 1. Showing Sound And Diseased Vines

| Variety                         | No. Ex-<br>amined. | No.<br>Sound. | No Dis-<br>eased. |
|---------------------------------|--------------------|---------------|-------------------|
| Black Cornichon.....            | 8                  | 4             | 4                 |
| Black Hamburg.....              | 3                  | 1             | 2                 |
| Black Malvoise.....             | 2                  | 0             | 2                 |
| Black Morocco....               | 15                 | 3             | 12                |
| Black Portugal.....             | 1                  | 1             | 0                 |
| Black Prince.....               | 3                  | 0             | 3(badly)          |
| Blue Spanish.....               | 2                  | 2             | 0                 |
| Cannonhall Muscat.....          | 1                  | 0             | 1                 |
| Carigan.....                    | 2                  | 2             | 0                 |
| Chasselas Croquant.....         | 2                  | 2             | 0                 |
| Chasselas de Florence.....      | 2                  | 2             | 0                 |
| Chasselas de Fontainbleau.....  | 5                  | 5             | 0                 |
| Chasselas Rose.....             | 6                  | 6             | 0                 |
| Early Madeleine.....            | 2                  | 1             | 1                 |
| Flame Tokay.....                | 7                  | 2             | 5                 |
| Gros Coleman.....               | 11                 | 11            | 0                 |
| Hausco.....                     | 3                  | 2             | 1                 |
| Jura Muscat.....                | 2                  | 2             | 0                 |
| Malaga.....                     | 7                  | 2             | 5                 |
| Mission.....                    | 36                 | 22            | 14                |
| Muscat of Alexandria.....       | 20                 | 15            | 5                 |
| Muscat Proceco Du Puy de Dome.. | 13                 | 12            | 1                 |
| Purple Damascus.....            | 3                  | 1             | 2                 |
| Rose d' Italie.....             | 1                  | 1             | 0                 |
| Rose of Peru.....               | 2                  | 0             | 2(badly)          |
| Sabal Kanski.....               | 11                 | 3             | 8                 |
| Sultana.....                    | 12                 | 11            | 1                 |
| Thompson's Seedless.....        | 30                 | 25            | 5                 |
| The Pierce*.....                | 15                 | 14            | 1                 |
| Trousseau.....                  | 2                  | 1             | 1                 |
| Verdel.....                     | 3                  | 1             | 2                 |
| White Sweet Water.....          | 3                  | 3             | 0                 |
| Wilder*.....                    | 25                 | 23            | 2                 |
| Zinfandel.....                  | 2                  | 2             | 0                 |

\*American grapes.



The disease had not advanced far enough to show any serious effects on the vines, except on the Black Prince and the Rose of Peru. These two varieties were so badly affected that the vines were beginning to die. On many of the diseased vines the crown-gall was just beginning to show on the crown. It is interesting to note that none of the Chasselas grapes or the Gros Coleman were found diseased.

## CULTURAL NOTES

### Propagation

The easiest and most common method of propagating the grape is by cuttings, though sometimes layering and grafting are employed. In growing grapes from cuttings there are two common ways practiced in the Mesilla Valley. The cuttings may either be planted permanently in the field in the fall or early spring, or they may be "rooted" in the nursery and afterwards transferred to the vineyard as rooted plants. Spring planting of cuttings in the field is more common than fall planting, though the latter is to be preferred. With fall-planted cuttings it is the practice to hill them up as soon as they are planted. This process consists in mounding the soil all around the cutting, 6 to 10 inches high. In the spring the middles are plowed and the cuttings uncovered. If the cuttings are planted in the spring, they are not covered up.

A great deal of care and close attention must be given to the field-planted cuttings the first season, in order to secure a good stand. Irrigation, especially, must not be neglected. When the cuttings have been rooted in the nursery, they can be transferred to the vineyard the following spring. It is a common practice in this section—and a quite satisfactory one—to wait until spring to "take" the cuttings from the vine and plant them out in the field. In fact, some take the cuttings while the vines are being pruned in the spring. A better method of spring planting is to take the cuttings in the fall and "heel" them during the winter. By doing this the cuttings tend to callous over, which seems to aid in the formation of roots. The length of cuttings used varies from

20 to 24 inches. Cuttings with short internodes are preferable.

#### **Depth to Plant Cuttings**

The depth depends, to a large degree, on the length of the cuttings. When the cuttings are of the average length of 20 to 24 inches, they can easily be planted from 12 to 16 inches deep. The lighter the soil, the deeper they may be planted. Two or three buds should remain above ground.

Some of the Mexican grape-growers place the cutting against one side in the hole, and bend in 3 to 6 inches of its lower portion. It is claimed that by doing this the cutting will root better. Immediately after the cuttings or rooted plants are set out they should be irrigated.

#### **Soil**

While the grape grows on a great variety of soils, it gives better satisfaction on a good loam. It has been noticed at the Station that those vines growing on the lighter soil have produced a more uniform growth, heavier crops, and larger and nicer bunches, than vines of the same varieties growing on the heavy adobe. There is also a marked tendency towards earlier ripening on the light soil. These observations agree, to a large extent, with the experience of the Mesilla Valley Mexican grape-growers, who, as a rule, have their vineyards on light soil.

#### **Distance Between Plants**

There is a wide difference of opinion in regard to the desirable distance between the vines; and this distance depends, to some degree, on the system of training the vines. If the vines are to be trained on trellises, it is better to allow more room than when the stump system of pruning is practiced.

When the vines are trained to the stump system and they are planted in squares, the distance varies from 8 x 8 to 10 x 10 feet. The former distance—8 x 8 feet—as a rule is preferable in this section. Some growers recommend planting 8 x 9 or 8 x 10 feet.

The number of vines to the acre depends on the distance at

which they are planted. In the following table the number of vines required per acre at given distances is given:

| Distance.        | Number of vines per acre. |
|------------------|---------------------------|
| 8 feet x 8 feet, | 682                       |
| 8 " x 9 "        | 605                       |
| 8 " x 10 "       | 544                       |
| 8 " x 11 "       | 495                       |
| 8 " x 12 "       | 454                       |
| 9 " x 9 "        | 437                       |
| 9 " x 10 "       | 484                       |
| 9 " x 11 "       | 440                       |
| 10 " x 10 "      | 437                       |

The number of vines per acre for any other distance, whether in squares or parallelograms, can be found by multiplying the distance in feet between the rows by the distance between the plants in the rows, and dividing this product into forty-three thousand five hundred and sixty, the number of square feet in an acre.

#### Staking the Vines

After the first season's growth it is desirable, though not necessary, to tie the vines to stakes which are driven down in the soil close to the plant. The vines are kept tied to the stakes until the stump is well formed. The stakes may be from 2½ to 3 feet in length, and from 2 to 3½ inches in diameter. The *tornillo* stakes are used in the Mesilla Valley. The object of staking vines is principally to help the vine grow upright, and thus produce a straight stem or stump. The stake will last two or three seasons, and by that time the vines will have formed the stump, and there will be no need of renewing the stakes. Strong binding twine can be used for tying the vines. This will have to be renewed each season. Most of the Mexican grape-growers use strips of the *Yucca* blade, which makes a very satisfactory tying material.

#### Pruning

The method generally practiced along the Rio Grande Valley by our grape-growers is that commonly known as the "stump system." The first year the cutting is allowed to grow at will. One, two, or more canes may grow during the

first season. The following spring the cane, or canes, are cut back to the height at which it is desired to start the head of the vine. This may be from 6 to 10 inches high. During the second season a number of canes will be produced from the shortened vine. The following spring (second pruning) is really the time when the more or less goblet form of the stump is started. The canes are cut back to one or two eyes, and any unnecessary cane that does not tend to aid in the formation of the regular shape of the vine had best be cut out. A light crop is produced this season. At the third pruning the vine is cut back, as in the previous year, to one or two eyes to the cane, and a heavier crop of fruit is produced. All subsequent pruning, proceeds upon the same plan. Always keep in mind the symmetry of the vine and the height of the stump; take out all unnecessary as well as all dead wood, and prune to one or two eyes. There is a tendency of the stump to become higher and higher each year, as the result of this method of pruning. See figure 4.

The pruning knife, pruning shears, a medium-sized saw, as well as a very small-bladed saw are common tools used in pruning. Our Mexican grapes-growers prefer the knife to the shears. The small-bladed saw is used principally to saw out dead stumps between growing ones. Some growers object to the use of the shears, since it is claimed that this tool tends to bruise the cells on the stump as the canes are cut. Whether this is the case or not, the vine, if properly pruned, never shows any noticeable injury. Quicker work can be done with the pruning shears than with the knife.



Fig. 4. Grape Vine Pruned According to the "Stump System" as Practiced in the Mesilla Valley.

### **Time to Prune**

Throughout the vine-growing districts along the Rio Grande Valley, the vineyards are pruned in the spring—just before growth begins. In the Mesilla Valley this is generally done during the latter part of March or about the first of April, one to two weeks after the uncovering of the vines.

### **Cultivation**

The system of cultivation practiced in this section is a very simple one. In the spring the ground is thoroughly plowed, and in doing this the hills are plowed down as much as possible. In about a week after the plowing the vines are uncovered and bordered off into narrow plats, two rows of vines to each plat. While this system of bordering the vineyards into such narrow plats is convenient in the irrigation of the plantation, it is not absolutely necessary; wider plats can be made, if the land is level enough. A week or two after the uncovering of the vineyard, it is pruned and irrigated. The summer work consists in keeping the plantation clean, which is done almost entirely by hoeing. The Mexican grape-growers use the cultivator very little. A great deal of labor can be saved by the use of the cultivator during the summer.

### **Irrigation**

Immediately after the vines are pruned they are flooded. The water is turned into the plats, which are allowed to fill up considerably before the water is taken off. The subsequent irrigations during the summer are given at intervals varying from three to five weeks. The drier the season, the more frequent the irrigations. As a rule the irrigation stops in the early part of August.

At the Station it has been the practice to irrigate the vineyard once during the winter. This practice is not considered of any value by our Mexican grape-growers; in fact, many of them contend that winter irrigation injures the vines. No detrimental effects have been noticed in the Station vineyard due to winter irrigation.

### Winter Covering or Hilling

It has always been the practice throughout the Rio Grande Valley to protect the vines during the winter. Very shortly after the crop is gathered in the fall the vines can be twisted and tied together with one of the longest canes. (See Fig. 5). Soon after the leaves are killed by the frost, the ground is plowed and the soil is hilled up all around the vine, from four to eight inches above the main body of the stump. When the vines are covered they appear like small conical hills. (See Fig. 6). The dirt is drawn up to the vine with a hoe or shovel. Most of our workmen prefer the former tool. In the Mesilla Valley the covering of the vines is usually done during the last two weeks in November. In the spring the dirt is plowed away from the vines. It is preferable to plow both ways, as by so doing there remains but a small amount of dirt around the vine to be pulled away. The dirt that is not plowed



Fig. 5. Grape Vines Tied Preparatory to Hilling Them for Winter.

away from around the vine is drawn to the middles with a hoe. A very general opinion prevails among the Mexican grape-growers that hilling the vines with moist soil is injurious to the plant. At the Station the vineyard has been hilled while the soil has been very moist, and no noticeable injurious results have been observed from this practice.

The *vinifera* grapes in the Mesilla Valley seem to be subjected to occasional winter injury. Vineyards that are left

uncovered are sometimes injured quite materially, especially if the winter is dry and very cold. If the winter is rainy and the humidity is high the unprotected vines do not show any winter injury. The practice of hilling the vines in winter practically insures the crop to the vineyardists.

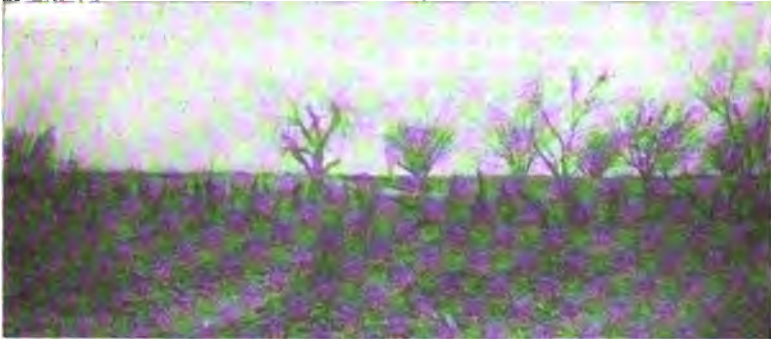


Fig. 6. Grape Vines Covered During Winter.

#### Uncovering the Vines

The vines should be uncovered a week or two before pruning. Do not delay the uncovering so long that when the vines are uncovered the buds on the portion of the canes protected have materially swollen and some have even burst. When uncovering is delayed too long, the base buds on the canes are usually the first ones to start. When the buds are in this condition they are partially, if not entirely, injured when the vines are uncovered. It is difficult to say just when to uncover the vines, but like many other horticultural operations, it must be governed to a large degree by climatic conditions, which the grower should consider in performing his work.

#### Insects

Very little, if any, damage is done by insects to the grape vine or fruit. The beetle (*Allorhina mutabilis*), locally known as "June bug", is sometimes found congregated in large numbers on the ripe bunches, which it entirely destroys.

As yet we know of no practicable remedy for it, but fortunately this insect is not a serious pest.

Occasionally a Vine Leaf Hopper has been reported to the Station as having been found on some of the vineyards. This insect sucks the sap from the leaves, causing them to turn yellow and fall, thus exposing the grapes to the sun. The Phylloxera, which is well known and dreaded by the California and European grape-growers of the *vinifera* varieties, resembles many of the plant lice and generally attacks the roots of the vine. No effectual remedy has yet been found, but its destructive work can be avoided by the use of resistant stocks. This insect has never been found at the Station, nor has it been reported from any part of the Territory.

#### Diseases

The only disease that is attracting attention at present is the crown-gall. This disease was first reported to the Experiment Station in the spring of 1903, by Brother James, President of the St. Nicholas Academy at Bernalillo, who discovered it on practically all of the vines of his five-acre vineyard. The writer, not being able to ascertain the nature of the trouble, sent some diseased grape specimens to the United States Department of Agriculture. The matter was referred to Mr. Geo. G. Hedgecock, Assistant Pathologist in the United States Laboratory of Pathology at St. Louis, Mo., who reported it a species of the crown-gall. At present there is practically no information to be had on this grape root disease. Some treatment experiments have been conducted in Brother James' vineyard at Bernalillo, under the direction of Mr. Hedgecock. In co-operation with the United States Department of Agriculture, Bureau of Plant Industry, this Station has begun work to ascertain varieties resistant to the crown-gall, the investigations on resistant stocks having been started with about 100 varieties of the *vinifera* group. On an examination of a number of vineyards, both at Bernalillo and Mesilla Park by Mr. Hedgecock and the writer, it was found that only a few of them were infested. In every case, how-



ever, all of the diseased vines found in the vineyards were plants of varieties that had been bought in California. In no case did we find a single native Mission vine affected. As already stated, Brother James' vineyard, composed of California-grown stock, was practically all diseased. Mr. Geo. M. Williams' vineyard of over an acre, near Las Cruces, was also found to be practically all seriously infested. The vines had been declining for some time, and had been unprofitable. All of these vines had been bought in California. With the exception of the two above mentioned vineyards, which were practically destroyed by the crown-gall, this disease has not been troublesome. The results of the first investigations on the crown-gall indicate that the disease has been introduced with the vines from California, and that the Valley Mission grape was resistant to the trouble. However, on examination of the Station's experimental vineyard in February, 1906, both the Mission and Muscat of Alexandria, which were propagated by cuttings from vineyards in the valley and planted in among the California bought varieties in the experimental vineyard, were found to be diseased. (See Table I). It is possible that the infection came from the California vines. On April 7, 1906, a number of Mission vines were found diseased in an old vineyard in Mesilla.

The grape crown-gall is easily recognized. It produces an abnormal wart-like growth on the plant. In the earlier stages, and when it is on the crown or roots, the galls are lighter in color and quite watery. Those appearing on the stump are darker and hardier. As the galls get older they become darker in color. The disease attacks the roots, crown, stump, and sometimes the canes. However, the galls are most commonly found at the crown of the plant, and they are here more numerous and larger than on any other part. The disease does not seem to be very injurious during the first few years.

The investigations of the crown-gall and methods for preventing the disease have been on co-operative basis between the

United States Department of Agriculture, Bureau of Plant Industry, and the New Mexico Experiment Station, and the following chapter has been written by Mr. Geo. G. Hedgcock, of the Bureau of Plant Industry, giving in a preliminary way some information on the crown-gall:

## THE CROWN-GALL DISEASE OF THE GRAPE VINE

by

GEORGE GRANT HEDGCOCK

Assistant in Pathology, United States Department of Agriculture.

The crown-gall disease of the grape, although it has attracted the attention of grape-growers in New Mexico only recently, is not a new disease, having been known for many years in California and for a longer time in France, Italy and Germany. It was probably introduced into New Mexico from California, since it has been found so rarely in vineyards planted with grape vines raised from cuttings of the Mission variety, so common in the territory.

The cause of the disease is not certainly known. Some investigators assert that the galls are due to bacteria, much like the galls of the tuberculosis of the olive; others assert that the galls are the result of injuries to the stem and roots by freezing, cultivation, etc. From numerous observations it appears to occur most frequently on the least hardy varieties of the European grape, *Vitis vinifera*, in the coldest localities where such grapes may be grown. On the other hand, galls may be produced on plants grown from seed in the greenhouse, where freezing never occurs. These and other facts not mentioned here, indicate that galls are contagious, and caused by some parasitic organism.

The disease is a serious drain upon the vitality of the vine. The gall growth is not covered by a natural layer of bark; in fact, it often ruptures the bark in its formation. Vines with galls lose much of their sap through the diseased region. The gall growth dies every winter in climates where freezing weather occurs, and the wood beneath the gall usually dies, also. The following season a new gall formation occurs from adjacent live tissues, which die the following winter. In a year or so, in susceptible varieties, the vine is encircled and dies, leaving the root alive. The root then sends up new shoots from below the diseased region, and these in turn are attacked by the disease. Badly diseased vines are worthless, since they bear but little fruit of a very poor quality.

The following varieties of California grapes are much subject to the

disease: Mission, Muscat of Alexandria, Flame Tokay, Rose of Peru, and Black Prince. The native Mission, of the variety that has been grown in the territory since the earliest days is also attacked by the disease, but not so badly as the variety of Mission sold in California. A number of varieties promise more or less resistance to the disease. The following varieties are freest from the disease: Sultana Seedless, Feher Zagos, White Sweet Water, Lenoir, Zinfandel, and Black Malvoise. A number of other varieties are being tested for resistance, and also for their adaptability to the climate and soil of the territory.

All means used in attempting to cure vines diseased with crown-gall have failed. The galls have been cut away, and the vines washed with copper, formalin, copperas, and other fungicides, without even retarding the disease, let alone curing it. The only hope for profit in the vine industry lies in finding varieties which are resistant. It is feared that if vine growers continue planting some varieties now grown, the growing of grape vines will cease in those parts of the territory where the disease has obtained a foothold.

All diseased vines should be destroyed, and care taken not to plant vines again in the same field for several years. The water should not be allowed to run from an infected vineyard to one not infected. Growers of vineyards should get cuttings from vines known to be healthy, and grow their own vines. Cuttings should be planted out in March, varying from the first of the month in Southern New Mexico to the latter part of the month farther north.

Owing to the prevalence of the crown-gall in California and New Mexico, and of the vine disease in the southern part of California, the purchase of vines should be made with great caution. The crown-gall disease is carried in cuttings from diseased plants, and in vines grown from such cuttings.

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### SUMMARY

I. The *vinifera* grapes are well adapted to the Rio Grande Valley conditions.

II. The American grapes are not grown for commercial purposes in the valley.

III. Early as well as late ripening kinds should be added to the commercial vineyards.

IV. Some varieties, like the Emperor, Black Morocco and Early Madeleine, are not well adapted to the stump system of pruning.

V. Nearly all the Chasselas group of grapes are small growing vines, and there are indications that they are more resistant to the crown-gall.

VI. None of the varieties sent from the United States Department of Agriculture has any particular merit.

VII. Vineyards can be started from cuttings planted in the spring in the field.

VIII. Vineyards will begin to bear the third season after planting.

IX. A light soil is preferable to a heavy one.

X. To insure against winter killing the vines may be hilled in the fall.

XI. The idea among many of our grape-growers that hilling the vines while the soil is quite wet, or irrigating the hilled vines during the winter is detrimental, cannot be substantiated from the results obtained at the New Mexico Experiment Station.

XII. Good crops can be matured with four to six irrigations during the growing season.

XIII. It is advisable to uncover the vines a week or so before pruning.

XIV. Many of the varieties including the Mission grape are subject to the crown-gall.

630,679  
N/G

## BULLETIN NO. 59

MAY, 1906

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New Mexico College of Agriculture and Mechanic Arts

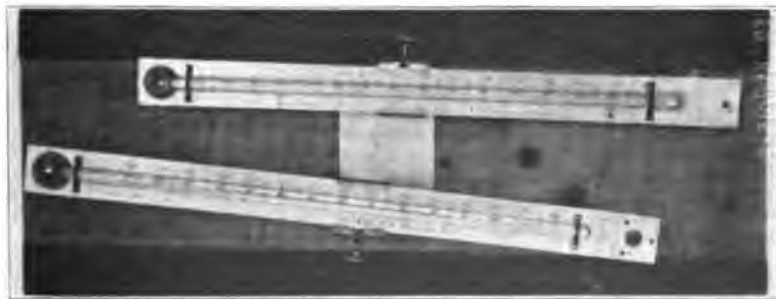
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AGRICULTURAL EXPERIMENT STATION

AGRICULTURAL COLLEGE, N. M.

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# FORTY YEARS OF SOUTHERN NEW MEXICO CLIMATE



Maximum and Minimum Thermometers

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BY

J. D. TINSLEY

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SANTA FE, N. M.:  
THE NEW MEXICAN PRINTING COMPANY.  
1906.

# NEW MEXICO AGRICULTURAL EXPERIMENT STATION

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The Bulletins of this Station will be mailed free to Citizens of New Mexico  
and to others as far as the editions printed will allow  
on application to the Director

## SUMMARY

This bulletin contains a record of the monthly and annual mean maximum, mean minimum, and mean temperatures\*, highest and lowest temperatures during each month, number of days with temperature of 32° or less, number of days with temperature of 60° or less, precipitation, relative humidity, condition of the sky, and wind movement for each month and year from 1892 to 1905 as observed at the New Mexico Experiment Station. Also, temperature and rainfall records for other stations in the Mesilla Valley for most of the years between 1851 and 1890.

The data have a general application to those portions of southern New Mexico having an altitude less than 4000 feet.

The annual mean maximum temperature for 14 years is 76.8°. The annual mean minimum for 13 years is 41.4° and the annual mean for 40 years is 61.6°. The lowest temperature in 14 years was 1° in Dec. 1895 and the highest, 106° which has occurred several times. Temperatures of 10° and less are not uncommon at night in Dec., Jan. and Feb.

The mean annual range of temperature is 35.4°. The absolute monthly range is from 45° to 75°. The greatest annual range was 101° in 1895.

The mean number of days in a year when the temperature does not rise above 60° is 56 and of the days when the temperature falls below 32° in the 24 hours is 121.

The mean annual rainfall is 8.8 inches. The smallest was 3.5 in. in 1873, and the largest, 17.1 in. in 1905. The most of the rain falls during July, August, and September. Snow occurs but the amount is too small to be of economic importance.

The records scarcely sustain the idea that there has been a permanent increase in the rainfall.

The relative humidity is low, the annual mean being probably about 40 per cent.

The mean monthly wind movement is about 5000 miles, 7 miles an hour.

The mean number of clear days per year is 225, part cloudy 91, and cloudy 49.

The evaporation is 5 to 6 feet per year.

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\* All temperatures in this bulletin are in degrees Fahrenheit.

## INTRODUCTION

In this bulletin will be found the meteorological data recorded at the New Mexico Agricultural College and Experiment Station from 1892 to 1905, inclusive, together with temperature and rainfall records at other stations in the Mesilla valley between 1851 and 1890, as published in a "Report on the Climate of New Mexico, with particular reference to questions of Irrigation and Water Storage in the Arid Region," by General A. W. Greely, Chief Signal Officer, and Lieut. W. A. Glassford, Signal Corps. Executive Document No. 287, House of Representatives, 51st Congress, 2nd Session.

The great extent of New Mexico, about 350 miles north to south and the same east to west, together with the varied topography, the elevations varying from about 3,000 feet in the southern portion to more than 13,000 feet at the tops of the highest mountain peaks, give wide variations in climate in the various localities, so that meteorological observations at a single station apply strictly to a limited area only.

The observations recorded in the following pages while only strictly applicable to the Mesilla valley will, in a general way, indicate the conditions which obtain in the southern portion of the territory at elevations of from 3,000 to 4,000 feet.

## DESCRIPTION OF THE LOCALITY

The Mesilla valley, in which the Experiment Station is located, is that portion of the valley of the Rio Grande extending from Fort Selden on the north, where the river cuts through the Selden Mountains, to within a few miles of El Paso, Texas, on the south, where the river again cuts through a mountain range. The total length of the valley is about 50 miles and the average width of the true river bottom land is about 5 miles.

A section on an east to west line passing through the Experiment Station grounds is as follows: Going west from the river there is about one mile of bottom land, then a rapid rise



—200 feet in 2 miles—up to a broad undulating plain. Going east, the bottom land is 4 miles wide; then comes a terrace about one-half mile wide sloping upward toward the east, with an average height of about 25 feet above the bottom land; then another rather abrupt rise of about 50 feet from which a rolling plain rises about 500 feet in the 10 miles to the foot of the Organ Mountains. The west face of the Organ Mountains rises rather abruptly to a height of 7,000 to 9,000 feet above sea level. The valley falls from north to south at a rate of about 3 feet per mile.

While the records of the several stations do not show any marked variation in temperature due to location, such variation if it exists being masked by annual fluctuations, yet the contour of the cross section probably exerts an influence on the temperatures of places in the valley. A minimum thermometer exposed in the Experiment Station orchard for a short period in the spring of two or three years showed a temperature one to two degrees below the minimum in the shelter. The orchard is located on river bottom land between the old and new locations of the thermometer shelter. It is not uncommon for some orchards to suffer severely from frost while others a few miles away are scarcely hurt. It is probable that orchards if planted on the first and second terraces above the bottom land would suffer much less from frost than those on the bottom land.

#### DESCRIPTION OF THE STATION AND EQUIPMENT.

From 1892 to 1899 the thermometer shelter was located near the Agricultural building, which is situated in the river bottom about one half mile west of the first terrace previously mentioned. The rain gage and anemometer were mounted on the roof of this building. While the location of the rain gage and anemometer was very satisfactory, the shelter containing the thermometers was probably a little screened by the building and shaded by a row of young trees.

On September 1, 1899, the thermometer shelter was re-

moved to the vicinity of the Science Hall, which is on the first terrace, about 200 yards east of its west edge, and about 25 feet above the former location; the rain gage and anemometer were placed on the top of this building. The thermometer shelter is now quite in the open; the anemometer is above any obstacles; but the rain gage is scarcely as advantageously placed as formerly.

The station is located two and one half miles southeast of Las Cruces and one mile northeast of Mesilla Park, Dona Ana County, N. M., in latitude  $32^{\circ} 15'$  N. and longitude  $106^{\circ} 45'$  W. The elevation of the ground above sea level is 3868 feet, according to a U. S. Geological Survey Bench Mark on a stone in front of the College Main Building.

The maximum and minimum temperatures are taken with U. S. Weather Bureau standard maximum and minimum thermometers which are kept in the standard form of shelter furnished by the Bureau to voluntary observers. This shelter is situated 75 yards northeast of the Science Hall, the door opens about north and the floor is 6 feet above the ground. The land around the shelter is covered with a rather heavy growth of Shad scale (*Atriplex canescens*) which shades the ground considerably, but there is much bare ground between the bushes.



Figure 1.

Figure 1 is a view toward the east showing in the foreground the thermometer shelter and character of the vegetation surrounding it. In the middle distance is seen the western edge of the second terrace and in the distance the Organ Mountains.

The rain gage is on the roof of the Science Hall, 40 feet above ground. There is a chimney to the south west and another to the north, each about 12 feet from the rain gage, and a short roof ridge to the northwest a little higher than the gage and about 15 feet distant; but these do not interfere seriously with its exposure.

The anemometer (Weather Bureau standard) is also located on the roof of the Science Hall with its cups 10 feet above the roof and 50 feet above the ground. The records are made on a single sheet register situated in the Physical Laboratory. The wind vane is also on the Science Hall.

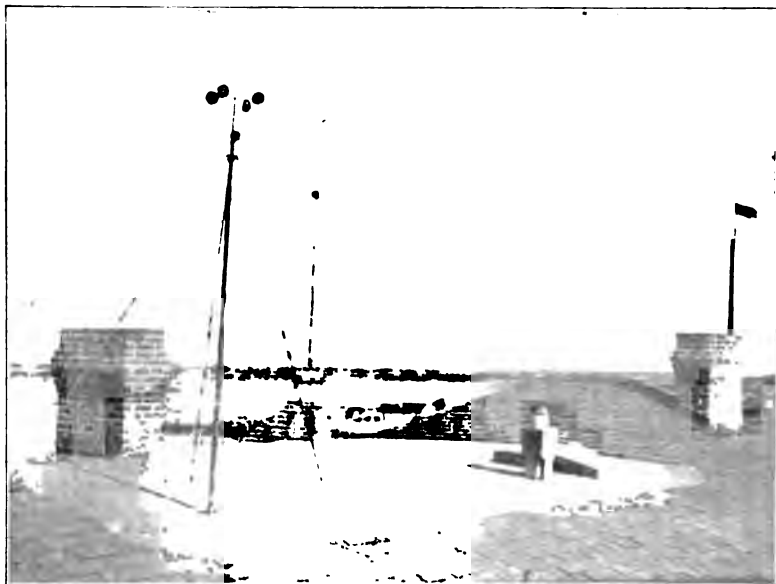


Figure 2.

Figure 2 shows the mounting of the rain gage, anemometer, and wind vane on the roof of the Science Hall and also the relations of the chimneys and roof ridge to the rain gage.

Description of the method of taking the relative humidity will be found in connection with the discussion of the table on the subject.

Barometric readings are also regularly recorded, but these have not been checked nor averaged, so cannot be published at this time.

From 1892 to September, 1899, the observations were taken at 6. a. m. and 6. p. m., but since that time, they have been taken at 8 a. m. and 5:30 to 6 p. m. local time.

The observations have been made in connection with the New Mexico Section of the U. S. Weather Bureau, which has furnished the instruments, by the following student assistants: Watt Gilmore, 1892-1895; Fabian Garcia, 1895-1896; C. E. Mead, 1896-1898; C. Thompson, 1898-1899; A. M. Sanchez, 1899-1902; and R. H. Hart, 1902-1905. The work was under the supervision of the Agricultural Department from 1892 to 1899, since which time it has been in the charge of the writer.

### METEOROLOGICAL DATA

In tables 1 to 14 will be found the meteorological data taken at the Experiment Station for each year and month in the year from 1892 to 1905.

All temperatures in this bulletin are in degrees Fahrenheit.

The data will be discussed in connection with the tables following in which the meteorological elements are given in separate tables making their comparison easier.

### TEMPERATURE

#### Mean Maximum and Mean Minimum

The maximum temperature for the preceding 24 hours is read at 5:30 p. m. from the maximum thermometer. The maximum thermometer differs from an ordinary thermometer in having its bore contracted just above the bulb.



Standard Mercurial  
Barometer

The increase in volume of the mercury, due to rise in temperature, forces the mercury up through the constriction; but when the temperature falls, the cohesion of the mercury is not sufficient to withdraw the column of mercury beyond the constriction, and it therefore remains in the tube showing the highest temperature reached. On the following morning it is whirled rapidly, which forces the excess of mercury back into the bulb.

The minimum temperature, which always occurs here during the night, is read each morning from the minimum thermometer. This differs from an ordinary thermometer in being filled with alcohol instead of mercury and in having a little index in the tube. The friction of the index against the walls of the tube prevents its being carried forward when the alcohol advances; but the surface tension at the end of the alcohol column is sufficient to pull it back as the column retreats, so that it marks the lowest point reached by the column. The minimum thermometer is set by raising the bulb end and allowing the index to slide down to the end of the alcohol column. The picture on the cover page shows the minimum and maximum thermometers, which are mounted nearly horizontally, the minimum being at the top.

Table 15 shows the mean maximum and table 16 the mean minimum temperatures for each month and year from 1892 to

1905, a period of 14 years. These results were obtained by dividing the sums of the highest, and lowest, temperature for each day in the month by the number of days in the month. The mean on the bottom line under each month is the average of the numbers for that month for the 14 year period. The annual means in the last column are the averages of the temperatures of the 12 months.

The various climatic elements can be most forcibly presented by comparisons and for this purpose, the data for other stations given in Bulletin O recently published by the U. S. Weather Bureau will be used in the following pages.

The mean maximum temperatures are all rather high. January has the same as Charleston, S. C., and Galveston, Texas; February, as Mobile, Ala., and San Diego, Cal.; March, as Vicksburg, Miss., and two degrees higher than Los Angeles, Cal.; April and May, as Jacksonville, Fla.; June is hotter than any of the cities on the gulf coast and somewhat cooler than southern Arizona; July, as Independence, Cal., and Montgomery, Ala.; August, as Shreveport, La.; September, as Key West, Fla.; October, as Mobile, Ala.; November, as New Orleans, La.; and December, as Wilmington, N. C. The mean annual maximum temperature is about that of Shreveport, La., and Jacksonville, Fla.

The mean minimum temperature comparisons are even more striking than are those of the mean maximums. For January, the mean minimum is that of Pittsburg Pa., and St. Louis, Mo., for February and March, that of Washington, D. C., for April, that of Atlantic City, N. J., and Tacoma, Wash., for May, that of Binghamton, N. Y., and Nantucket, Mass., for June, that of Los Angeles, Cal., and Rochester, N. Y., for July, that of San Diego, Cal., and Rochester, N. Y., for August and September, that of Milwaukee, Wis., for October, that of Minneapolis, Minn., for November, that of Spokane, Wash., for December, that of Boston, Mass. The mean annual minimum is about that of New Haven, Conn., and Chicago, Ill.

The comparisons of the temperatures are more clearly

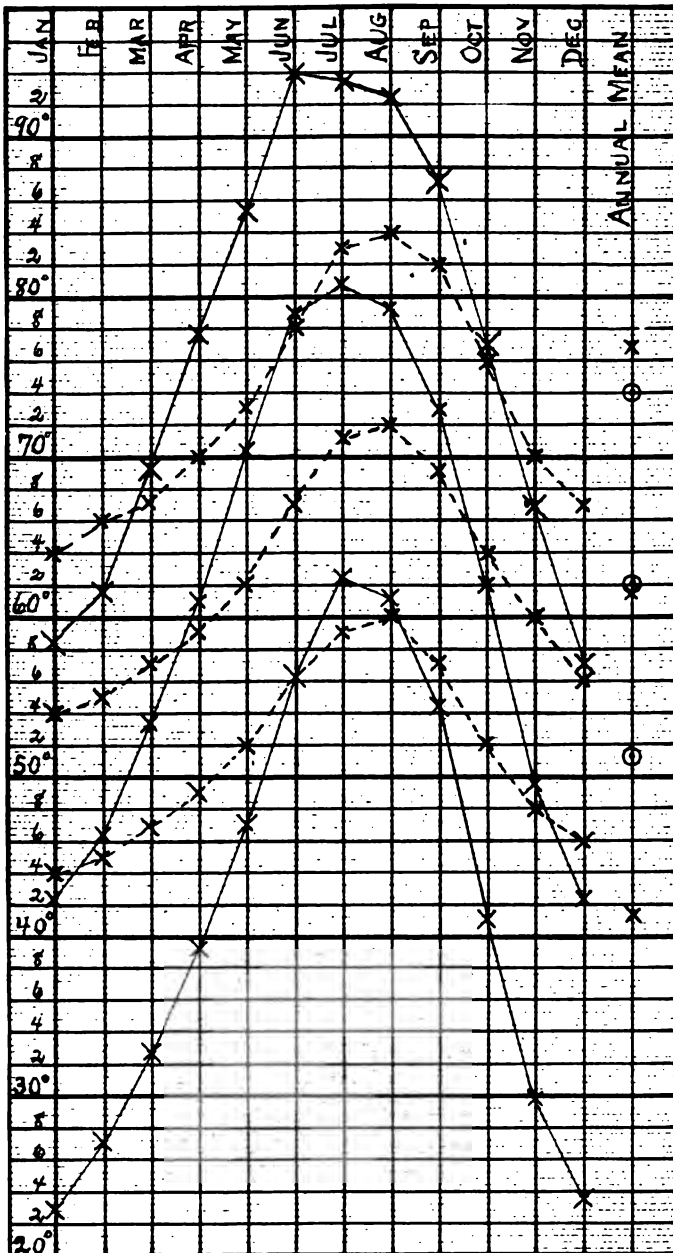


Diagram No. 1. Comparison of the mean maximum mean minimum, and mean temperatures at N. M. Expt. Station, solid line, and Los Angeles, Cal., broken line. Annual mean, the X indicates Expt. Sta. and the circles Los Angeles.

shown in diagrams Nos. 1 and 2. Diagram No. 1 shows the mean maximum, mean minimum, and mean temperature for each month, and the annual means for this Station and Los Angeles, Cal. The temperatures are indicated by the X's; the lines joining them simply enable the eye to follow the curves more conveniently. Diagram 2 shows the temperatures at this station and at Memphis, Tenn.

These diagrams indicate how two places having the same annual mean temperature may yet vary considerably in the temperatures of the various months.

These comparisons are intended to impress on the mind of the reader the fact that while the annual mean temperature is high ( $61.6^{\circ}$ ) that this is made up of a high maximum and comparatively low minimum, and that this low minimum is the controlling factor in the agriculture of the region.

While the days are hot in summer, they are never severely cold in winter, as the low temperatures are mainly confined to the nights. The cool nights and the dry atmosphere make the summer heat much less disagreeable than one unfamiliar with the climate would imagine. In fact, the degree of discomfort experienced from higher temperatures depends upon both the temperature and the moisture in the air. With the dry atmosphere in the Mesilla Valley the heat sensation is about that experienced at a temperature 10 to 20 degrees lower in a more humid region. Sunstroke is practically unknown in this region.

#### **Mean Monthly and Annual Temperatures**

Table 17 contains the mean monthly and annual temperatures for a period of 55 years, but unfortunately these are not continuous so that the monthly means are averages of from 42 to 46 years and the mean annual temperature is the average for 40 years. The monthly means are the sums of the mean maximum and mean minimum for each month divided by two. The annual means are the averages of the monthly means for the year and the mean annual temperature is the average of the annual means for the period.



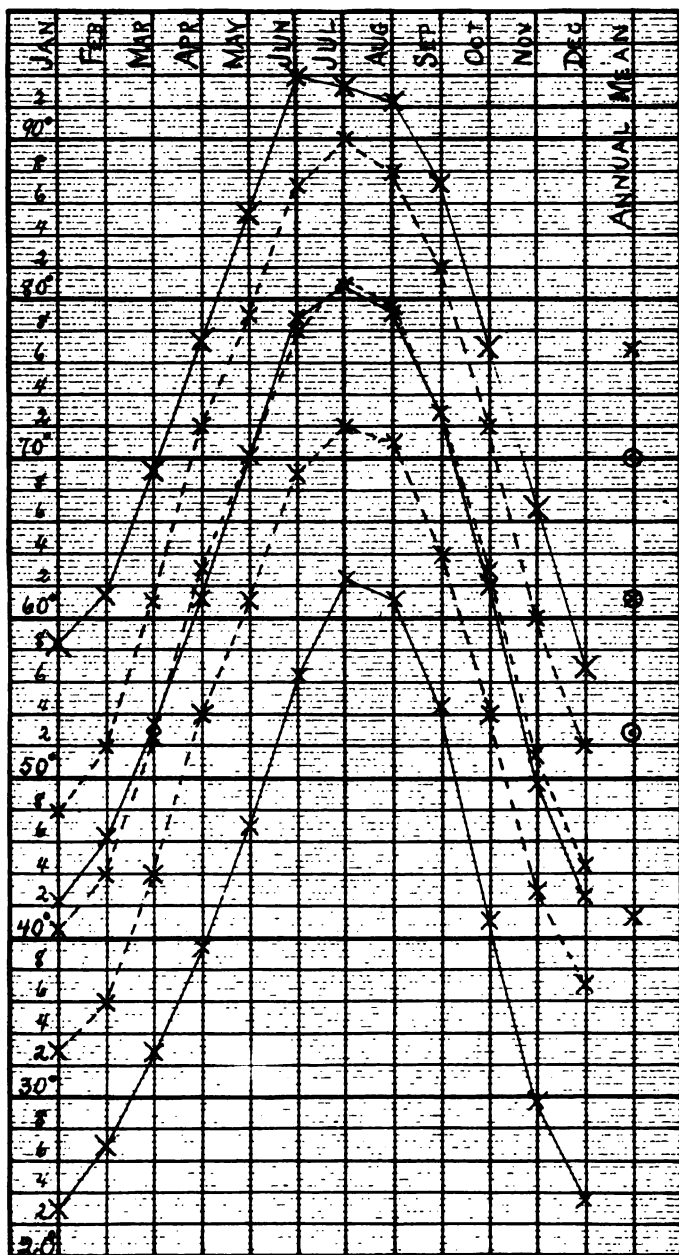


Diagram No. 2, Comparison of the mean maximum, mean minimum, and mean temperatures at N. M. Expt. Station, solid line, and Memphis, Tenn., broken line. Annual mean the X indicates Expt. Sta. and the circles, Memphis.

From 1854 to 1861 the records were taken at Fort Fillmore by a voluntary observer. Fort Fillmore was situated about 6 miles south of the present station, on the first terrace near its west edge and about 4 miles east of the river. The conditions were practically the same as those at the present station.

From 1865 to 1877 the records were taken at Fort Selden by a voluntary observer. Fort Selden was about 25 miles north, a little west, of the present station, on the second terrace (the first terrace is absent there), about one half mile from the river. The adjacent country is hilly and at this point the Rio Grande cuts through a ridge, the east end of which rises into the Doña Ana Mountains, or hills, and the west into the Selden Mountains.

From 1877 to 1882 a second-order station of the Signal Service was located in the town of Mesilla about three miles west of the present station and one mile east of the river.

In 1886 the station at Mesilla was abandoned and observations resumed at Fort Selden, where they were continued until October, 1890.

In 1892 the observations were begun at the New Mexico Experiment Station as already described.

As previously suggested, a consideration of mean temperature alone may lead to erroneous conclusions regarding a climate and especially the climate of places in the arid region.

The annual mean temperature of the locality is  $61.6^{\circ}$ \*, which is the same as that of Atlanta, Ga., Little Rock, Ark., Memphis, Tenn., and Los Angeles, Cal.—places from one to two degrees of latitude further north. This mean is made up of a mean maximum of  $76.8^{\circ}$ †, which is the same as that of places about two degrees of latitude further south on the Gulf coast and of other places of the same latitude as this station, in the Mississippi valley; and a mean minimum of  $41.4^{\circ}$ \*\*, the same as that of inland places 10 degrees further

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\* Mean of 40 years.

† Mean of 14 years.

\*\* Mean 13 years.

north. While the annual mean is that of Los Angeles, Cal., yet the mean minimum is nearly  $10^{\circ}$  below that of Los Angeles. The lowest temperature recorded at Los Angeles is  $28^{\circ}$  (Feb., 1883), while table 19 shows a temperature of  $1^{\circ}$  in December, 1895, and of  $2^{\circ}$  in February, 1899, while temperatures of  $10^{\circ}$  and less are not uncommon during December, January, and February. Further than this, tables 19 and 21 show that while the temperature is usually above  $32^{\circ}$  in May yet in 1899 there were five nights when it was  $32^{\circ}$  or less, the lowest recorded being  $27^{\circ}$ . The temperature gets below  $35^{\circ}$  in May of nearly every year. As previously stated, it is these low night temperatures that prohibit the growing of certain plants which the mean might lead one to expect to grow here. For example, the growth of the plams which add so much to the beauty of southern California is impossible in the open and the hardiest of the Eucalypts are killed back to the ground each year.

#### Range of Temperature

Table 18 shows the highest and Table 19 the lowest temperatures recorded each month. In some cases these temperatures occurred on more than one day in the month. The highest temperature recorded for the summer months is  $106^{\circ}$  and a temperature of  $100^{\circ}$  occurred frequently. These temperatures are not higher than those recorded for many places in other parts of the United States but their frequency of occurrence is greater.

The difference between the maximum and minimum for a day is called the daily range, and the average of these, which is the same as the difference between the mean maximum and the mean minimum for the month, is called the mean daily or mean monthly range. The difference between the highest and lowest temperatures recorded for the month is the absolute monthly range. The mean annual range is the difference between the mean annual maximum and mean annual minimum, and the absolute annual range is the difference between

the highest and lowest temperatures recorded during the year.

On comparing tables 15 and 16, it is found that the mean monthly range—taking the whole period—for January is  $35.3^{\circ}$ ; for February,  $34.8^{\circ}$ ; for March,  $36.5^{\circ}$ ; for April,  $38.4^{\circ}$ ; for May,  $38.6^{\circ}$ ; for June,  $37.6^{\circ}$ ; for July,  $30.8^{\circ}$ ; for August,  $30.9^{\circ}$ ; for September,  $32.9^{\circ}$ ; for October,  $36.2^{\circ}$ ; for November,  $38.1^{\circ}$ ; and for December,  $34.1^{\circ}$ . The mean annual range is  $35.4^{\circ}$ .

Taking means from Tables 18 and 19, we find that the absolute monthly range in January is liable to be as much as  $60^{\circ}$ , and in 1892 and 1904 it was  $67^{\circ}$ ; in February,  $64^{\circ}$  with maximum of  $74^{\circ}$  in 1899; in March,  $64^{\circ}$  with maximum of  $74^{\circ}$  in 1896; in April,  $60^{\circ}$  with maximum of  $67^{\circ}$  in 1897; in May  $61^{\circ}$  with maximum of  $70^{\circ}$  in 1896; in June,  $58^{\circ}$  with maximum of  $62^{\circ}$ ; in July,  $48^{\circ}$  with maximum of  $54^{\circ}$ ; in August,  $45^{\circ}$  with maximum of  $55^{\circ}$  in 1900; in September,  $54^{\circ}$  with maximum of  $65^{\circ}$ ; in October,  $60^{\circ}$  with maximum of  $71^{\circ}$  in 1898; in November,  $60^{\circ}$  with maximum of  $72^{\circ}$  in 1898; and in December,  $59^{\circ}$  with maximum of  $68^{\circ}$  in 1893.

The absolute range in 1895 was  $101^{\circ}$ .

The range of temperature here, in common with other localities in the arid region, is seen to be great.

#### **Number of Days with a Temperature of $60^{\circ}$ or Less**

Table 20 shows the number of days in each month when the temperature did not rise above  $60^{\circ}$ . The mean number of such days per year is 56, of which 17 occur in December, 17 in January, and 11 in February; or in other words, 38 per cent of the days of the winter months have a temperature of more than  $60^{\circ}$ . This aids materially in avoiding the necessity for providing shelter for stock and allows field operations on the farm to be carried on with comfort nearly every day in the winter.

#### **Number of Days (Nights) with Temperature of $32^{\circ}$ or less**

Table 21 shows the number of days, the low temperature nearly always occurring at night, in each month when the

temperature was  $32^{\circ}$  or less. These data emphasize the low temperature of the nights in winter and spring and show the liability to late frosts, which are the most serious drawback to fruit culture.

### PRECIPITATION.

The precipitation is measured by means of the rain gage, the parts of which are shown in Figure 3. It consists of a galvanized cylinder 6 in. in diameter and 22 in. high, called the overflow, in which is placed a brass tube 2.5 in. in diameter and 20 in. high called the measuring tube. The receiver

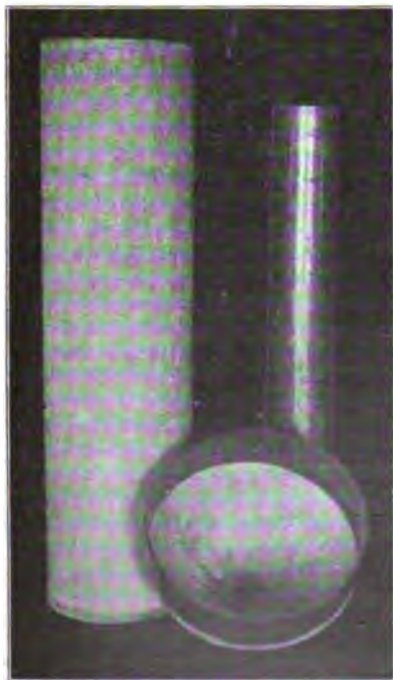


Figure 3. Standard Rain Gage.

The depth of the water in the tube is measured with a stick graduated to tenths of an inch; one tenth on the stick corresponds to one hundredth of an inch of rain.

fits as a cap on the overflow; its rim is 2 in. high and the bottom is conical with an opening in the center, under which the tube is placed. The water is caught in the tube, whose area is one-tenth of that of the receiver, so that the depth of water in it is 10 times as great as the depth of the rain that fell in the area of the receiver. In case the rainfall is greater than can be caught by the measuring tube, the surplus is caught by the overflow and poured into the tube for measurement.

The snow collected by the gage is melted and the water measured; if this is impossible, then a cone is cut out by pushing the overflow into the snow, partially melting the contents and measuring the water.

Table 22 gives the total monthly and annual precipitation for each month and year, and also the mean monthly and annual precipitation for the period. The monthly means are averages of from 43 to 46 years and the annual mean is the average of 41 years. The stations at which the records were obtained have been previously described.

The rainfall is very irregularly distributed through the months of the year, and for the same month in the different years. The annual rainfall is also very irregular, the mean is 8.82 in.; but in 1873 there were only 3.49 in.; and in 1894 only an inch more, while in 1881 there were 15.05 in. and in 1905, 17.10. July, August, and September are the rainy months, receiving about 57 per cent. of the total. June, October, and November receive about 22 per cent., while January, February, March, April, May, and December only receive about 21 per cent.

In 1858-9, 1869-70, 1871-2, 1901-2, and 1903-4, the rainfall between December and the following June did not exceed .25 in. From September, 1858, to July, 1859, there was only .14 in., and from July, 1859, to June, 1861, there were only 10.6 in. of rain.

Diagram No. 3 shows the mean rainfall of this station compared with that of Los Angeles, Cal., and Memphis, Tenn. This diagram begins with November, instead of January, in order to bring out more strongly the comparison between this station and Los Angeles. At Los Angeles the greatest rainfall occurs in the winter months, while here it is in the summer. The total mean annual rainfall at this station is 8.8 in. At Los Angeles, about 17.4 in., while at Memphis it is about 54 in.

The precipitation in the winter months frequently occurs as snow, but the amount is so small and it disappears so rapidly that it is not of economic importance. The snow is

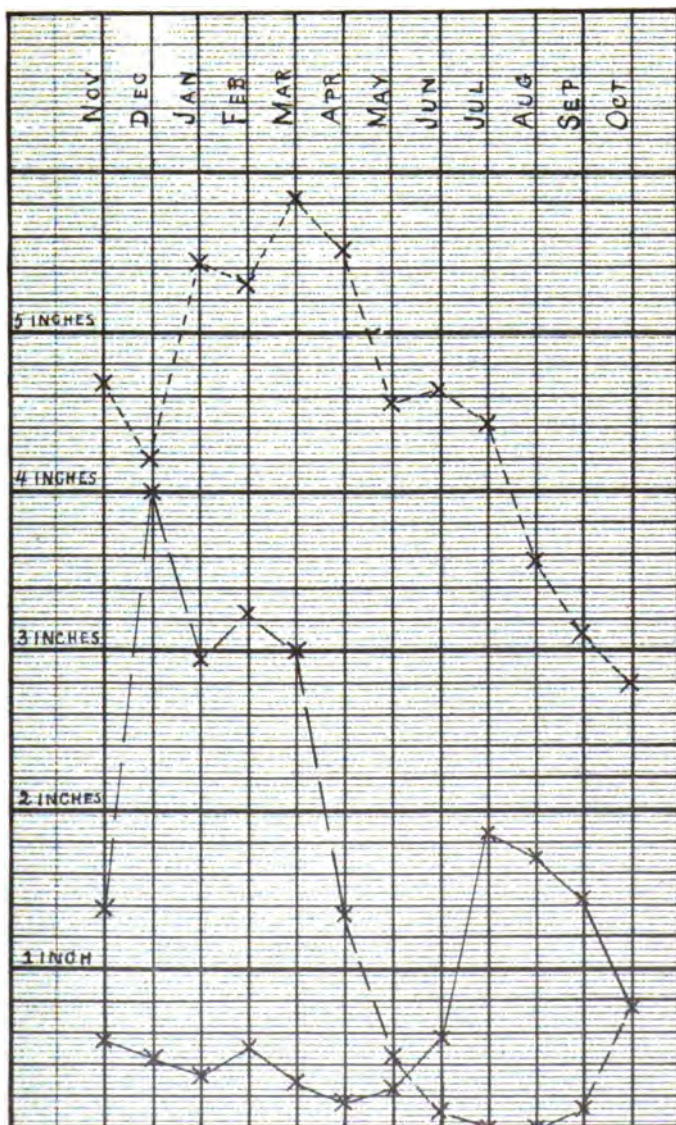


Diagram No. 3. Comparison of the mean monthly rainfall at N. M. Expt. Station, solid line, Los Angeles Cal., broken line, and Memphis, Tenn., dotted line. Data from Monthly Weather Review for 1905.

not deep enough and does not stay on the ground long enough to interfere seriously with the cattle on the ranges.

The rainfall, while not sufficient to aid materially the growth of crops, irrigation being a necessity, is sufficient in most years to produce large amounts of the native grasses which serve as the principal feed of the range stock.

The question, "is the rainfall increasing in the arid region?" is frequently asked. The records of the past five years might seem to indicate that it is; but the irregularities in the rainfall for the whole period are such, that definite conclusions can scarcely be drawn; especially, since in this 5-year period there were two severe droughts, December, 1901, to June, 1902, and October, 1903, to June, 1904.



## RELATIVE HUMIDITY



Fig: 4.  
Sling Psychrometer.

Table 23 gives the mean relative humidity for each month. The mean for the month was obtained by taking the average of the morning and evening observations for each day and averaging them.

By relative humidity is meant the percentage of moisture present of the total amount that the air could hold at that temperature. For example, if the relative humidity of the air is 50 per cent that means that there is only one-half as much moisture in the air at that time as there would be if the air contained all of the moisture that it could hold at that temperature.

The relative humidity is obtained by means of the psychrometer, Figure 4, which consists of two thermometers mounted on a metal strip and so arranged that they can be rapidly whirled. One of the thermometers has its bulb naked and the other has its covered with a layer of thin muslin. The muslin covered bulb is wet and then the thermometers are whirled until the temperature of both becomes constant. The evaporation of the water cools the wet bulb and the amount of cooling varies with the amount of moisture in the air. Knowing the difference in temperature between the wet and dry bulb thermometers

and the temperature of the air, given by the dry bulb, by reference to a set of tables the relative humidity is found. Another form of the instrument has the thermometers fixed and the covering of the wet bulb thermometer consists of a piece of cotton wick, which dips into a vessel of water placed underneath.

The observations here—at least, several years prior to 1900—were taken by pouring water over the naked bulb of one of the thermometers, and this did not allow sufficient evaporation to cool it to the lowest point, and therefore the relative humidity readings were too high. Since 1900, the sling psychrometer has been used and the readings are in most cases lower. Then, too, prior to 1900, the readings were made at 6 a. m. and 6 p. m. Since that time, they have been made 2 hours later in the morning and in winter, often an hour earlier in the evening; the air temperature being higher at 8 a. m. and 5 p. m., the relative humidity would be lower.

Bearing in mind the influence of temperature, the percentages of relative humidity will be seen to follow in a general way the rainfall of the months. The dry spells of January to July, 1902 and 1904, are clearly indicated by the low relative humidity and the wet year of 1905, by the highest mean for the six years.

Relative humidity is a matter of great importance, not only to persons seeking a dry climate from considerations of health, but also to the farmer. An extremely dry atmosphere is not only a disadvantage to most crops, but it is also an important factor in evaporation from water and soil surfaces. It means an increased loss of water from reservoirs and from the soil. Larger amounts of water must be used in irrigation when the air is abnormally dry, as was the case in the spring and early summer of 1902 and 1904. On the other hand, the comparatively low relative humidity favors rapid evaporation of perspiration from the surface of the body which exerts such a cooling effect that one only feels a temperature about that of the wet bulb thermometer, instead of the actual temperature of the air.

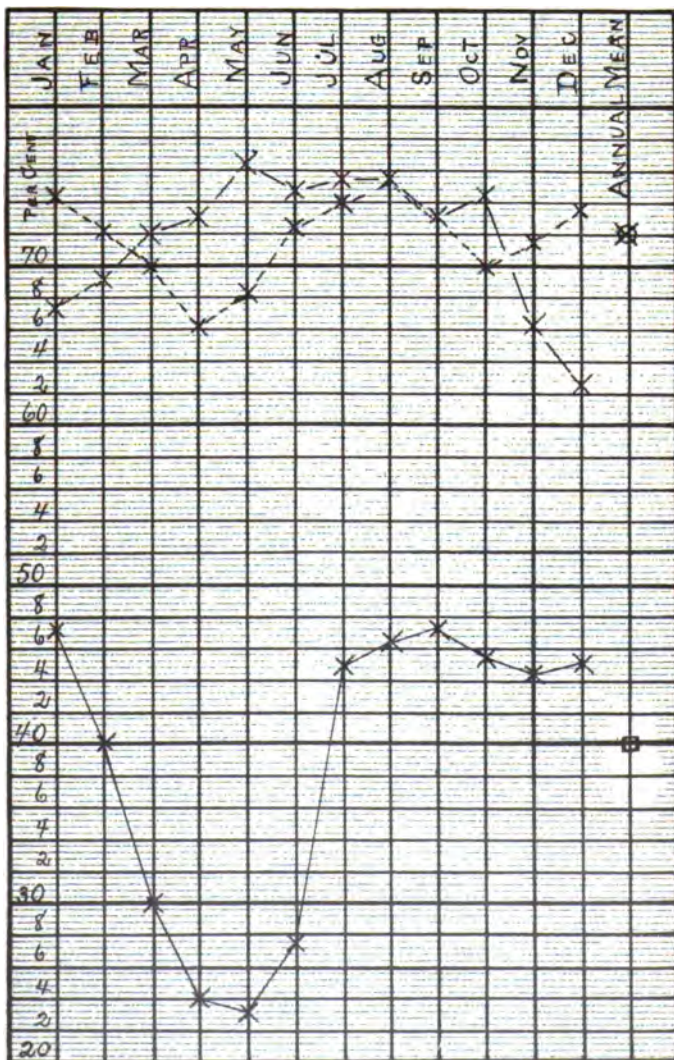


Diagram No. 4 Comparison of the mean monthly relative humidity at El Paso, Tex., solid line, Los Angeles, Cal., broken line, and Memphis, Tenn., dotted line. Annual mean, El Paso indicated by square, Los Angeles and Memphis, by crossed circle.

Bulletin O, U. S. Weather Bureau, gives the annual mean from 1891-1904 for El Paso; Texas, as 38.8 per cent, which is much nearer the true value for this station than 51 per cent.

The low percentages of relative humidity are, of course, only found in the arid region. Independence, Cal., has an annual mean relative humidity of 29.7 per cent; Denver, Colo., 48.7 per cent; Carson City, Nev., 50.2 per cent; Salt Lake City, Utah, 52.8 per cent; Los Angeles, Cal., 71.7 per cent; and Jacksonville, Fla., 79.5 per cent.

Diagram No. 4 shows a comparison between the relative humidity at El Paso, Texas, Los Angeles, Cal., and Memphis, Tenn. The data for El Paso instead for this station are used, because they represent the conditions more accurately than do the figures in Table No. 23.

#### WIND MOVEMENT

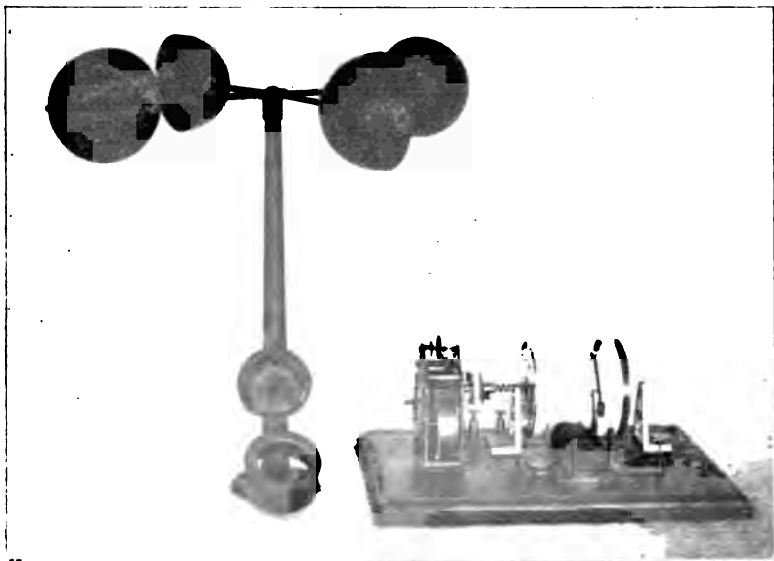


Fig. 5. Anemometer and Register.

The wind movement is measured by means of the anemometer (See Figure 5), which consists of four hemispherical

cups fastened to cross arms which are mounted on a vertical axis at the lower end of which is a worm gear that connects with the wheels of the dial register. This dial is so worked that the readings may be made directly from it; but it is more convenient to have the instrument make a permanent record, which is done by means of special register. This register consists of a drum driven by a clock which causes it to make four revolutions in 24 hours. There is a thread on the axis of the drum which causes it to advance a definite distance for each revolution. A ruled record sheet is fastened around the drum. A pencil is attached to the armature of an electro magnet with its point bearing on the paper. One wheel of the dial register, which makes one turn for 10 miles, has a pin set in it for each mile. These pins strike a spring which closes the electric circuit and the armature carrying the pencil is moved back, making a mark at right angles to the direction of motion of the drum. The pin soon passes and the pencil flies back to its original position in which it marks a spiral line on the paper. The cups make a certain number of revolutions for each mile of wind that passes and the miles are thus recorded. The maximum velocities are obtained from the number of miles passing in a five minute period. The record of the number of miles for each day is recorded on one sheet; and by counting the marks, the record of the total number of miles for each day is obtained.

Table 27 shows the total wind movement in miles for each month, and table 28 shows the wind movement calculated to miles per hour: March and April are the months with most wind; but May, February, and June are nearly equal to them.

Winds reaching a velocity of 75 miles per hour have occurred in several years, usually between the first and tenth of April, but really destructive storms of the nature of cyclones or tornadoes are unknown. The high winds of the spring months are very disagreeable because of the dust and sand which they carry. They also cause great losses of

water from the soil by increasing evaporation. As yet, the people have done very little to protect themselves from them by planting wind breaks of trees which would materially lessen their injurious effects. While occasional wind storms occur during the other months, the wind is usually a good breeze which adds to, rather than detracts from, comfort. There are very few periods when the wind velocity is not sufficient for running windmills which are widely used for lifting water, mainly for stock and household use; and to some extent, for irrigation. The prevailing direction of all of the winds with any considerable velocity is from the west, although an occasional high wind comes from the south. Forty-eight to seventy-two hours of continuous south wind is usually accompanied by increased cloudiness and often by rain, especially the settled rains. The thunder storms usually come from the mountains either on the east or northwest.

#### Sky

Tables 24, 25, and 26 give the general character of the sky with regard to cloudiness for each month. At the time of the morning and evening observations, the observer estimates as accurately as possible the number of tenths of the sky that are covered by clouds; also keeping a general watch on the condition for the day. If 0 to .3 of the sky has been covered for the day, it is called clear; if .4 to .7 have been obscured, then it is called part cloudy; and if more than .7 was obscured, then it is called cloudy.

Table 24 gives the number of cloudy days which will be found to average 2 to 7 per month, the mean annual total being 49. The greatest number for any month was 14, in July, 1901.

Table 25 shows the number of part cloudy days. The mean annual total is 91, nearly twice the number of cloudy days, with a monthly mean of 4 to 12. The greatest number was 25, in August, 1894.

Table 26 gives the number of clear days per month, which average 14 to 22 per month, with a mean annual total of 225.

New Mexico is called the "Land of Sunshine," and these figures sustain the reputation for this portion of the territory. Fully 65 per cent of the days of the winter and spring months have less than .4 of the sky covered with clouds each day.

### EVAPORATION

The evaporation records in Table 29 were obtained from a 3 foot cubical tank sunk into the ground until its rim was about 3 inches above the surface. It was surrounded by wire netting to keep out animals and birds. The tank was located near the thermometer shelter. The depth was measured each week and when the surface had been lowered about 3 inches, water was added until the level was raised to within about an inch of the rim.

The data for 1905 were obtained from the same tank in connection with work on irrigation. The tank was removed from its former position and placed about a quarter of a mile west in an alfalfa field in the river bottom. The alfalfa was cut at the same time as the balance of the hay crop, so that the tank was considerably shaded by it for several weeks at a time during May and June, which probably partially accounts for the less amount of evaporation.

Evaporation depends on wind movement, relative humidity, and temperature. The mean annual wind movement was about the same in 1900 and 1901 and a little above normal in both years. The mean relative humidity was 6 per cent. lower in 1900 than in 1901 and below normal each year, assuming 40 per cent. as normal. The mean temperature for the two years was about the same and slightly below normal. From the foregoing conditions it seems probable that the mean total evaporation in this locality is 5 to 6 feet per year.

In 1905 the wind movement and mean temperature were below normal, and the relative humidity above normal; all of which would tend to decrease the evaporation.

Professor L. G. Carpenter, in Colorado Experiment Station bulletin 45, gives the mean evaporation from a similar tank at Fort Collins, Colo., for 7 years between 1887 and 1897, as 40.97 inches, with a maximum of 46.71 in. and a minimum of 37.84 in. This is a little more than half of the amount shown by the record of this Station.

Table 1—Year 1892

| Month.   | Temperature.  |               |               |                           |                          |                             | Precipitation. | Relative humidity per cent. | Sky                    |                             |                       | Wind                       |                                       |
|----------|---------------|---------------|---------------|---------------------------|--------------------------|-----------------------------|----------------|-----------------------------|------------------------|-----------------------------|-----------------------|----------------------------|---------------------------------------|
|          | Mean Maximum. | Mean Minimum. | Monthly Mean. | Highest during the Month. | Lowest during the Month. | Number of days 32° or less. |                |                             | Number of days cloudy. | Number of days part cloudy. | Number of days clear. | Wind Movement total miles. | Wind Movement average miles per hour. |
| Jan....  | 56.6          | 22.0          | 39.3          | 71                        | 4                        | 27                          | 0.87           | 58                          | 7                      | 6                           | 16                    | 3280                       | 4.4                                   |
| Feb....  | 61.4          | 30.9          | 46.1          | 73                        | 13                       | 18                          | 0.36           | 50                          | 4                      | 0                           | 25                    | 403                        | 5.6                                   |
| March... | 66.6          | 34.6          | 50.7          | 83                        | 23                       | 11                          | 0.46           | 68                          | 4                      | 0                           | 25                    | 683                        | 5.6                                   |
| April... | 76.5          | .....         | .....         | 88                        | .....                    | 3                           | 0.08           | 66                          | 4                      | 0                           | 25                    | 450                        | 5.6                                   |
| May....  | 82.2          | .....         | .....         | 93                        | .....                    | .....                       | 1              | 49                          | 0                      | 0                           | 21                    | 280                        | 5.6                                   |
| June.... | 93.2          | .....         | .....         | 103                       | .....                    | .....                       | 0.03           | 75                          | 0                      | 0                           | 25                    | 200                        | 5.6                                   |
| July.... | 96.0          | .....         | .....         | 103                       | .....                    | .....                       | 1.32           | 77                          | 0                      | 0                           | 14                    | 200                        | 5.6                                   |
| Aug....  | 92.4          | 61.5          | 76.9          | 96                        | 54                       | 0                           | 0.75           | 77                          | 2                      | 17                          | 17                    | 286                        | 5.6                                   |
| Sept.... | 90.2          | 30.6          | 70.5          | 86                        | 29                       | 0                           | 0.05           | 65                          | 2                      | 2                           | 23                    | 200                        | 5.6                                   |
| Oct....  | 71.6          | 39.6          | 55.6          | 77                        | 29                       | 0                           | 0.30           | 65                          | 2                      | 2                           | 23                    | 200                        | 5.6                                   |
| Nov....  | 63.2          | 30.6          | 47.2          | 73                        | 12                       | 26                          | 1.47           | 74                          | 2                      | 11                          | 16                    | 200                        | 4.3                                   |
| Dec....  | 55.0          | 26.1          | 40.5          | 74                        | 12                       | 26                          | 0.47           | 71                          | 2                      | 11                          | 16                    | 200                        | 4.3                                   |
| Total..  | .....         | .....         | .....         | .....                     | .....                    | 112                         | 6.47           | .....                       | 27                     | 83                          | 256                   | 3715                       | 5.1                                   |
| Mean..   | 76.1          | .....         | .....         | .....                     | .....                    | .....                       | .....          | 61                          | .....                  | .....                       | .....                 | .....                      | .....                                 |

Table 2—Year 1893

| Month.   | Temperature   |               |               |                           |                          |                             | Precipitation | Relative Humidity per cent. | Sky                    |                             |                       | Wind                       |                                       |
|----------|---------------|---------------|---------------|---------------------------|--------------------------|-----------------------------|---------------|-----------------------------|------------------------|-----------------------------|-----------------------|----------------------------|---------------------------------------|
|          | Mean Maximum. | Mean Minimum. | Monthly Mean. | Highest during the month. | Lowest during the month. | Number of days 32° or less. |               |                             | Number of days cloudy. | Number of days part cloudy. | Number of days clear. | Wind Movement total miles. | Wind Movement average miles per hour. |
| Jan....  | 61.4          | 25.5          | 43.4          | 73                        | 10                       | 28                          | 0.07          | 65                          | 0                      | 11                          | 20                    | 3900                       | 5.2                                   |
| Feb....  | 60.1          | 30.8          | 45.4          | 71                        | 14                       | 18                          | 1.26          | 66                          | 4                      | 11                          | 13                    | 4500                       | 4.7                                   |
| March... | 67.7          | 33.6          | 50.6          | 87                        | 21                       | 12                          | 0.02          | 58                          | 2                      | 13                          | 16                    | 6500                       | 5.7                                   |
| April... | 78.9          | 38.3          | 58.6          | 91                        | 29                       | 5                           | 0.00          | 46                          | 1                      | 4                           | 25                    | 5200                       | 7.2                                   |
| May....  | 83.4          | 46.2          | 64.8          | 93                        | 33                       | 0                           | 0.77          | 51                          | 3                      | 9                           | 19                    | 5500                       | 7.4                                   |
| June.... | 97.5          | 56.9          | 77.2          | 105                       | 46                       | 0                           | 0.00          | 50                          | 0                      | 16                          | 14                    | 4500                       | 6.3                                   |
| July.... | 93.3          | 63.6          | 78.4          | 106                       | 56                       | 0                           | 2.04          | 60                          | 4                      | 17                          | 10                    | 3300                       | 4.5                                   |
| Aug....  | 88.0          | 52.0          | 75.0          | 96                        | 51                       | 0                           | 4.19          | 72                          | 3                      | 11                          | 17                    | 3200                       | 4.3                                   |
| Sept.... | 86.0          | 54.4          | 70.2          | 95                        | 39                       | 0                           | 2.39          | 69                          | 6                      | 11                          | 13                    | 3400                       | 4.7                                   |
| Oct....  | 77.9          | 35.6          | 56.7          | 87                        | 27                       | 9                           | 0.03          | 65                          | 0                      | 8                           | 23                    | 3000                       | 4.0                                   |
| Nov....  | 68.4          | 23.5          | 44.9          | 81                        | 15                       | 29                          | 0.03          | 68                          | 2                      | 2                           | 26                    | 3100                       | 4.3                                   |
| Dec....  | 61.9          | 23.5          | 42.7          | 77                        | 9                        | 29                          | 0.02          | 59                          | 1                      | 10                          | 20                    | 3800                       | 5.1                                   |
| Total..  | .....         | .....         | .....         | .....                     | .....                    | 126                         | 10.82         | .....                       | 26                     | 123                         | 216                   | 4156                       | 5.7                                   |
| Mean..   | 76.9          | 41.1          | 59.0          | .....                     | .....                    | .....                       | .....         | 61                          | .....                  | .....                       | .....                 | .....                      | .....                                 |



**Table 3—Year 1894**

| Month.     | Temperature   |               |               |                           |                          |                             | Precipitation. | Relative Humidity per cent. | Sky                         |                        |                             | Wind                  |                            |                                       |
|------------|---------------|---------------|---------------|---------------------------|--------------------------|-----------------------------|----------------|-----------------------------|-----------------------------|------------------------|-----------------------------|-----------------------|----------------------------|---------------------------------------|
|            | Mean Maximum. | Mean Minimum. | Monthly Mean. | Highest during the month. | Lowest during the month. | Number of days 32° or less. |                |                             | Number of days 60° or less. | Number of days cloudy. | Number of days part cloudy. | Number of days clear. | Wind Movement total miles. | Wind Movement average miles per hour. |
| Jan.....   | 55.9          | 18.5          | 37.2          | 71                        | 2                        | 30                          | 20             | 0.08                        | 5                           | 2                      | 20                          | 3800                  | 4.8                        |                                       |
| Feb.....   | 56.5          | 19.5          | 38.5          | 71                        | 5                        | 24                          | 15             | 0.05                        | 5                           | 5                      | 11                          | 4300                  | 6.4                        |                                       |
| March..... | 65.0          | 30.4          | 47.9          | 85                        | 15                       | 19                          | 7              | 0.26                        | 4                           | 1                      | 15                          | 6000                  | 8.1                        |                                       |
| April..... | 73.8          | 40.4          | 56.6          | 89                        | 30                       | 5                           | 0              | 0.02                        | 5                           | 0                      | 15                          | 5400                  | 7.6                        |                                       |
| May.....   | 86.8          | 48.6          | 66.7          | 95                        | 34                       | 0                           | 0              | 0.00                        | 5                           | 0                      | 12                          | 19                    | 5000                       | 6.7                                   |
| June.....  | 93.4          | 51.7          | 72.5          | 102                       | 41                       | 0                           | 0              | 0.00                        | 4                           | 0                      | 7                           | 23                    | .....                      | .....                                 |
| July.....  | 95.4          | 59.7          | 77.5          | 103                       | 48                       | 0                           | 0              | 0.62                        | 4                           | 0                      | 12                          | 19                    | 4600                       | 6.2                                   |
| Aug.....   | 90.2          | 60.6          | 75.4          | 90                        | 0                        | 0                           | 0              | 2.06                        | 3                           | 0                      | 25                          | 6                     | 4000                       | 5.4                                   |
| Sept.....  | 88.0          | 50.3          | 69.3          | 94                        | 40                       | 0                           | 0              | 0.18                        | 3                           | 0                      | 15                          | 15                    | 3000                       | 4.2                                   |
| Oct.....   | 81.0          | 43.4          | 62.2          | 91                        | 23                       | 6                           | 0              | 0.47                        | 6                           | 0                      | 8                           | 23                    | 2800                       | 3.8                                   |
| Nov.....   | 72.7          | 25.3          | 49.0          | 82                        | 15                       | 29                          | 0              | 0.00                        | 5                           | 0                      | 28                          | 2700                  | 3.8                        |                                       |
| Dec.....   | 58.3          | 31.0          | 44.7          | 70                        | 15                       | 16                          | 19             | 0.73                        | 6                           | 9                      | 15                          | 7                     | 2100                       | 2.8                                   |
| Total..... | .....         | .....         | .....         | .....                     | .....                    | 129                         | 61             | 4.47                        | .....                       | 17                     | 138                         | 210                   | .....                      | .....                                 |
| Mean.....  | 77.1          | 40.1          | 58.6          | .....                     | .....                    | .....                       | .....          | .....                       | 56                          | .....                  | .....                       | 3964                  | 5.4                        |                                       |

**Table 4—Year 1895**

| Month.     | Temperature   |               |               |                           |                          |                             | Precipitation. | Relative Humidity per cent. | Sky                         |                        |                             | Wind                  |                            |                                       |
|------------|---------------|---------------|---------------|---------------------------|--------------------------|-----------------------------|----------------|-----------------------------|-----------------------------|------------------------|-----------------------------|-----------------------|----------------------------|---------------------------------------|
|            | Mean Maximum. | Mean Minimum. | Monthly Mean. | Highest during the month. | Lowest during the month. | Number of days 35° or less. |                |                             | Number of days 60° or less. | Number of days cloudy. | Number of days part cloudy. | Number of days clear. | Wind Movement total miles. | Wind Movement average miles per hour. |
| Jan.....   | 56.3          | 24.9          | 40.6          | 66                        | 13                       | 25                          | 16             | 0.45                        | 65                          | 6                      | 13                          | 12                    | 3000                       | 4.0                                   |
| Feb.....   | 57.4          | 21.1          | 40.7          | 82                        | 5                        | 21                          | 16             | 0.60                        | 69                          | 5                      | 7                           | 16                    | 3600                       | 5.4                                   |
| March..... | 69.7          | 31.7          | 50.7          | 82                        | 19                       | 17                          | 2              | 0.01                        | 60                          | 2                      | 8                           | 21                    | 3600                       | 4.8                                   |
| April..... | 78.4          | 40.1          | 59.2          | 88                        | 28                       | 5                           | 2              | 0.00                        | 63                          | 0                      | 9                           | 21                    | 4400                       | 6.1                                   |
| May.....   | 84.1          | 45.3          | 65.1          | 96                        | 34                       | 0                           | 0              | 0.52                        | 55                          | 1                      | 10                          | 20                    | 4067                       | 5.5                                   |
| June.....  | 91.0          | 46.3          | 72.6          | 99                        | 37                       | 0                           | 0              | 0.10                        | 58                          | 3                      | 13                          | 18                    | 3500                       | 4.8                                   |
| July.....  | 90.6          | 61.4          | 76.1          | 102                       | 56                       | 0                           | 0              | 3.08                        | 73                          | 11                     | 14                          | 6                     | 4050                       | 5.4                                   |
| Aug.....   | 89.3          | 59.8          | 74.5          | 94                        | 53                       | 0                           | 0              | 2.19                        | 77                          | 6                      | 13                          | 12                    | 3400                       | 5.1                                   |
| Sept.....  | 87.1          | 53.6          | 70.3          | 96                        | 35                       | 0                           | 1              | 0.96                        | 77                          | 7                      | 6                           | 17                    | 4110                       | 5.7                                   |
| Oct.....   | 73.3          | 38.7          | 56.0          | 82                        | 26                       | 1                           | 0              | 1.20                        | 62                          | 6                      | 6                           | 19                    | 3700                       | 5.0                                   |
| Nov.....   | 62.7          | 28.3          | 45.5          | 73                        | 19                       | 21                          | 9              | 0.45                        | 82                          | 2                      | 10                          | 18                    | 4950                       | 6.9                                   |
| Dec.....   | 55.5          | 19.3          | 37.4          | 68                        | 1                        | 29                          | 22             | 0.32                        | 68                          | 4                      | 3                           | 24                    | 4470                       | 6.0                                   |
| Total..... |               |               |               |                           |                          | 119                         | 68             | 9.83                        | .....                       | 53                     | 112                         | 200                   | .....                      | .....                                 |
| Mean.....  | 74.6          | 40.2          | 57.4          | .....                     | .....                    | .....                       | .....          | .....                       | 69                          | .....                  | .....                       | .....                 | 3710                       | 5.4                                   |

Table 5—Year 1896

| Month.   | Temperature   |               |               |                           |                          |                             | Precipitation. | Relative Humidity per cent. | Sky                    |                             |                       | Wind                       |                                       |
|----------|---------------|---------------|---------------|---------------------------|--------------------------|-----------------------------|----------------|-----------------------------|------------------------|-----------------------------|-----------------------|----------------------------|---------------------------------------|
|          | Mean Maximum. | Mean Minimum. | Monthly Mean. | Highest during the month. | Lowest during the month. | Number of days 32° or less. |                |                             | Number of days cloudy. | Number of days part cloudy. | Number of days clear. | Wind Movement total miles. | Wind Movement average miles per hour. |
| Jan....  | 60.5          | 29.4          | 41.4          | 71                        | 9                        | 26                          | 14             | 0.31                        | 63                     | 6                           | 10                    | 4150                       | 5.6                                   |
| Feb....  | 60.2          | 29.6          | 41.9          | 75                        | 10                       | 24                          | 14             | 0.11                        | 65                     | 4                           | 14                    | 4400                       | 6.3                                   |
| March... | 71.3          | 30.1          | 50.7          | 89                        | 15                       | 18                          | 3              | 0.00                        | 52                     | 9                           | 8                     | 7000                       | 9.4                                   |
| April... | 77.3          | 35.2          | 56.2          | 87                        | 23                       | 10                          | 3              | 0.11                        | 55                     | 4                           | 11                    | 6600                       | 9.2                                   |
| May....  | 88.0          | 46.2          | 67.1          | 101                       | 31                       | 2                           | 0              | 0.10                        | 43                     | 5                           | 9                     | 5450                       | 7.3                                   |
| June.... | 96.2          | 57.2          | 76.7          | 104                       | 46                       | 0                           | 0              | 1.01                        | 48                     | 5                           | 9                     | 5000                       | 6.9                                   |
| July.... | 98.7          | 62.7          | 78.2          | 98                        | 57                       | 0                           | 0              | 2.50                        | 72                     | 11                          | 15                    | 4100                       | 5.5                                   |
| Aug....  | 92.3          | 59.1          | 75.7          | 99                        | 54                       | 0                           | 0              | 0.47                        | 68                     | 5                           | 16                    | 4200                       | 5.6                                   |
| Sept.... | 88.7          | 55.7          | 71.2          | 96                        | 44                       | 0                           | 0              | 1.24                        | 70                     | 14                          | 11                    | 4200                       | 5.8                                   |
| Oct....  | 73.2          | 44.1          | 58.6          | 83                        | 29                       | 1                           | 0              | 2.14                        | 80                     | 13                          | 12                    | 3650                       | 4.9                                   |
| Nov....  | 68.9          | 30.6          | 49.7          | 78                        | 15                       | 19                          | 8              | 0.06                        | 63                     | 2                           | 20                    | 4000                       | 5.6                                   |
| Dec....  | 63.0          | 22.4          | 42.7          | 70                        | 11                       | 29                          | 5              | T                           | 60                     | 1                           | 8                     | 3900                       | 5.2                                   |
| Total..  | .....         | .....         | .....         | .....                     | .....                    | 129                         | 43             | 7.99                        | .....                  | 63                          | 135                   | 167                        | .....                                 |
| Mean...  | 77.3          | 40.8          | 59.0          | .....                     | .....                    | .....                       | .....          | .....                       | 62                     | .....                       | .....                 | 4720                       | 6.4                                   |

Table 6—Year 1897

| Month.    | Temperature   |               |               |                           |                          |                             | Precipitation. | Relative Humidity per cent. | Sky                    |                             |                       | Wind                       |                                       |
|-----------|---------------|---------------|---------------|---------------------------|--------------------------|-----------------------------|----------------|-----------------------------|------------------------|-----------------------------|-----------------------|----------------------------|---------------------------------------|
|           | Mean Maximum. | Mean Minimum. | Monthly Mean. | Highest during the Month. | Lowest during the Month. | Number of days 32° or less. |                |                             | Number of days cloudy. | Number of days part cloudy. | Number of days clear. | Wind Movement total miles. | Wind Movement average miles per hour. |
| Jan....   | 54.3          | 23.9          | 39.1          | 68                        | 9                        | 29                          | 26             | 0.35                        | 71                     | 11                          | 9                     | 4900                       | 6.6                                   |
| Feb....   | 62.8          | 24.3          | 43.5          | 77                        | 16                       | 23                          | 11             | 0.00                        | 65                     | 4                           | 17                    | 5250                       | 7.2                                   |
| March...  | 68.5          | 31.7          | 50.1          | 79                        | 15                       | 17                          | 5              | 0.46                        | 56                     | 3                           | 10                    | 4700                       | 9.0                                   |
| April...  | 79.2          | 37.1          | 58.1          | 88                        | 21                       | 7                           | 0              | 0.23                        | 56                     | 3                           | 23                    | 6150                       | 8.5                                   |
| May....   | 86.4          | 50.0          | 68.2          | 93                        | 36                       | 0                           | 0              | 1.54                        | 58                     | 1                           | 14                    | 5800                       | 7.8                                   |
| June....  | 92.6          | 55.9          | 74.2          | 101                       | 43                       | 0                           | 0              | 0.07                        | 58                     | 4                           | 12                    | 5150                       | 7.1                                   |
| July....  | 90.7          | 61.6          | 76.1          | 96                        | 51                       | 0                           | 0              | 2.25                        | 71                     | 11                          | 14                    | 4500                       | 6.1                                   |
| August... | 89.7          | 60.0          | 74.8          | 98                        | 50                       | 0                           | 0              | 1.16                        | 72                     | 6                           | 15                    | 4200                       | 5.6                                   |
| Sept....  | 83.0          | 55.4          | 69.2          | 90                        | 46                       | 0                           | 0              | 2.14                        | 74                     | 10                          | 10                    | 3700                       | 5.2                                   |
| Oct....   | 75.5          | 40.5          | 58.0          | 88                        | 28                       | 7                           | 5              | 0.73                        | 70                     | 3                           | 13                    | 4000                       | 5.4                                   |
| Nov....   | 71.2          | 24.0          | 50.1          | 73                        | 20                       | 25                          | 3              | T                           | 59                     | 1                           | 26                    | 3650                       | 5.1                                   |
| Dec....   | 58.9          | 18.8          | 38.8          | 68                        | 9                        | 30                          | 17             | 0.03                        | 59                     | 2                           | 9                     | 4800                       | 6.4                                   |
| Total..   | .....         | .....         | .....         | .....                     | .....                    | 138                         | 67             | 8.96                        | .....                  | 59                          | 124                   | 182                        | .....                                 |
| Mean...   | 76.0          | 40.6          | 58.3          | .....                     | .....                    | .....                       | .....          | .....                       | 64                     | .....                       | .....                 | 4900                       | 6.7                                   |

Table 7—Year 1898

| Month.    | Temperature   |               |               |                           |                          |                             | Precipitation. | Relative Humidity per cent. | Sky                    |                             |                       | Wind                       |                                       |
|-----------|---------------|---------------|---------------|---------------------------|--------------------------|-----------------------------|----------------|-----------------------------|------------------------|-----------------------------|-----------------------|----------------------------|---------------------------------------|
|           | Mean Maximum. | Mean Minimum. | Monthly Mean. | Highest during the month. | Lowest during the month. | Number of days 32° or less. |                |                             | Number of days cloudy. | Number of days part cloudy. | Number of days clear. | Wind Movement total miles. | Wind Movement average miles per hour. |
| Jan....   | 54.5          | 19.7          | 37.1          | 68                        | 7                        | 29                          | 21             | 0.3%                        | 62                     | 8                           | 16                    | 4600                       | 6.2                                   |
| Feb....   | 67.4          | 26.1          | 46.7          | 78                        | 15                       | 24                          | 5              | 0.02                        | 57                     | 7                           | 18                    | 3850                       | 5.7                                   |
| March...  | 67.2          | 31.4          | 49.3          | 77                        | 12                       | 15                          | 5              | 0.26                        | 54                     | 9                           | 14                    | 5700                       | 7.7                                   |
| April...  | 77.4          | 43.3          | 60.3          | 90                        | 29                       | 2                           | 0              | 0.69                        | 54                     | 4                           | 11                    | 7150                       | 9.9                                   |
| May....   | 82.5          | 42.9          | 62.7          | 91                        | 32                       | 1                           | 0              | T                           | 54                     | 3                           | 9                     | 5600                       | 7.5                                   |
| June....  | 89.5          | 54.8          | 72.2          | 100                       | 42                       | 0                           | 0              | 1.83                        | 59                     | 12                          | 16                    | 5060                       | 7.0                                   |
| July....  | 90.4          | 61.2          | 75.8          | 102                       | 52                       | 0                           | 0              | 2.18                        | 65                     | 12                          | 4                     | 4700                       | 6.3                                   |
| August... | 91.1          | 59.6          | 75.4          | 97                        | 53                       | 0                           | 0              | 2.43                        | 65                     | 13                          | 9                     | 4300                       | 5.8                                   |
| Sept....  | 87.7          | 48.9          | 68.3          | 95                        | 39                       | 0                           | 0              | 1.74                        | 62                     | 5                           | 18                    | 3550                       | 4.9                                   |
| Oct....   | 80.6          | 32.8          | 56.7          | 91                        | 20                       | 14                          | 0              | T                           | 50                     | 0                           | 24                    | 3800                       | 5.1                                   |
| Nov....   | 67.0          | 25.0          | 46.0          | 81                        | 9                        | 23                          | 8              | 0.43                        | 49                     | 4                           | 20                    | 4500                       | 6.2                                   |
| Dec....   | 50.0          | 20.7          | 35.4          | 68                        | 10                       | 30                          | 26             | 1.25                        | 57                     | 6                           | 14                    | .....                      | .....                                 |
| Total     | .....         | .....         | .....         | .....                     | .....                    | 138                         | 65             | 11.21                       | .....                  | 66                          | 108                   | .....                      | .....                                 |
| Mean...   | 75.2          | 38.9          | 57.1          | .....                     | .....                    | .....                       | .....          | .....                       | 57                     | .....                       | 191                   | 4800                       | 6.6                                   |

Table 8—Year 1899

| Month.   | Temperature   |               |               |                           |                          |                             | Precipitation. | Relative Humidity per cent. | Sky                    |                             |                       | Wind                       |                                       |
|----------|---------------|---------------|---------------|---------------------------|--------------------------|-----------------------------|----------------|-----------------------------|------------------------|-----------------------------|-----------------------|----------------------------|---------------------------------------|
|          | Mean Maximum. | Mean Minimum. | Monthly Mean. | Highest during the month. | Lowest during the month. | Number of days 32° or less. |                |                             | Number of days cloudy. | Number of days part cloudy. | Number of days clear. | Wind Movement total miles. | Wind Movement average miles per hour. |
| Jan....  | 58.2          | 19.6          | 38.9          | 69                        | 8                        | 30                          | 20             | 0.05                        | 50                     | 1                           | 10                    | 4750                       | 6.3                                   |
| Feb....  | 60.5          | 20.3          | 40.3          | 76                        | 2                        | 26                          | 12             | 0.09                        | 48                     | 2                           | 19                    | 6150                       | 9.2                                   |
| March... | 72.3          | 29.4          | 50.8          | 86                        | 15                       | 20                          | 0              | 0.19                        | 43                     | 0                           | 20                    | 7700                       | 10.4                                  |
| April... | 76.7          | 36.7          | 56.7          | 87                        | 25                       | 8                           | 0              | 0.13                        | 49                     | 9                           | 8                     | 5770                       | 8.0                                   |
| May....  | 84.7          | 40.2          | 62.4          | 93                        | 27                       | 5                           | 0              | T                           | 44                     | 5                           | 10                    | 5550                       | 7.5                                   |
| June.... | 91.4          | 53.1          | 72.2          | 94                        | 36                       | 0                           | 0              | 0.63                        | 53                     | 4                           | 10                    | 5050                       | 7.0                                   |
| July.... | 92.9          | 60.2          | 76.6          | 101                       | 55                       | 0                           | 0              | 4.54                        | 66                     | 8                           | 11                    | 4100                       | 5.5                                   |
| Aug....  | 93.8          | 57.3          | 75.6          | 99                        | 51                       | 0                           | 0              | 1.81                        | 64                     | 3                           | 11                    | 3550                       | 4.8                                   |
| Sept.... | 90.0          | 47.6          | 68.8          | 101                       | 36                       | 0                           | 0              | 0.77                        | 59                     | 2                           | 26                    | 3925                       | 5.0                                   |
| Oct....  | 78.2          | 39.7          | 58.9          | 90                        | 27                       | 6                           | 0              | 0.03                        | 52                     | 4                           | 24                    | 5700                       | 7.7                                   |
| Nov....  | 69.1          | 32.1          | 50.6          | 82                        | 20                       | 19                          | 5              | 1.20                        | 51                     | 3                           | 21                    | 4550                       | 6.3                                   |
| Dec....  | 57.7          | 25.2          | 41.4          | 75                        | 16                       | 28                          | 18             | 0.23                        | 62                     | 10                          | 17                    | 4250                       | 5.7                                   |
| Total    | .....         | .....         | .....         | .....                     | .....                    | 142                         | 55             | 9.67                        | .....                  | 51                          | 98                    | .....                      | .....                                 |
| Mean...  | 77.1          | 38.4          | 57.8          | .....                     | .....                    | .....                       | .....          | .....                       | 54                     | .....                       | 221                   | 5060                       | 6.9                                   |

Table 9—Year 1900

| Month.        | Temperature   |               |               |                           |                          |                             | Precipitation. | Relative Humidity per cent. | Sky                    |                             |                       | Wind                       |                                       |
|---------------|---------------|---------------|---------------|---------------------------|--------------------------|-----------------------------|----------------|-----------------------------|------------------------|-----------------------------|-----------------------|----------------------------|---------------------------------------|
|               | Mean Maximum. | Mean Minimum. | Monthly Mean. | Highest during the month. | Lowest during the month. | Number of days 32° or less. |                |                             | Number of days cloudy. | Number of days part cloudy. | Number of days clear. | Wind Movement total miles. | Wind Movement average miles per hour. |
| Jan....       | 62.5          | 26.8          | 44.6          | 71                        | 17                       | 25                          | 0.33           | 53                          | 4                      | 7                           | 20                    | 3965                       | 5.3                                   |
| Feb....       | 63.9          | 28.8          | 46.4          | 78                        | 11                       | 19                          | 0.42           | 41                          | 6                      | 3                           | 19                    | 6065                       | 9.0                                   |
| March..       | 72.8          | 37.1          | 55.0          | 86                        | 20                       | 5                           | 1.36           | 44                          | 8                      | 4                           | 19                    | 5820                       | 7.8                                   |
| April... 12.4 | 34.3          | 54.4          | 83            | 29                        | 6                        | 0                           | 0.31           | 40                          | 4                      | 10                          | 16                    | 7240                       | 10.0                                  |
| May....       | 88.2          | 50.1          | 69.2          | 98                        | 32                       | 0                           | 0.88           | 32                          | 4                      | 6                           | 21                    | 7650                       | 10.2                                  |
| June....      | 89.3          | 56.6          | 78.4          | 106                       | 47                       | 0                           | 0.16           | 37                          | 5                      | 7                           | 18                    | 5530                       | 7.7                                   |
| July....      | 95.6          | 64.8          | 80.2          | 103                       | 53                       | 0                           | 1.52           | 49                          | 11                     | 4                           | 16                    | .....                      | .....                                 |
| August..      | 88.7          | 60.4          | 78.2          | 102                       | 47                       | 0                           | 0.90           | 44                          | 6                      | 8                           | 17                    | 5320                       | 7.2                                   |
| Sept....      | 89.2          | 59.0          | 74.1          | 97                        | 46                       | 0                           | 1.80           | 49                          | 7                      | 6                           | 15                    | 5485                       | 7.6                                   |
| Oct....       | 79.8          | 43.7          | 61.8          | 91                        | 29                       | 2                           | 0.45           | 42                          | 5                      | 8                           | 23                    | 5275                       | 7.1                                   |
| Nov....       | 70.0          | 29.4          | 49.7          | 80                        | 20                       | 20                          | 0.23           | 33                          | 6                      | 2                           | 22                    | 4120                       | 5.7                                   |
| Dec....       | 60.5          | 21.3          | 40.9          | 70                        | 14                       | 30                          | 0.04           | 29                          | 5                      | 3                           | 23                    | 4330                       | 5.8                                   |
| Total..       | .....         | .....         | .....         | .....                     | .....                    | 107.                        | 8.40           | .....                       | 71                     | 65                          | 229                   | .....                      | .....                                 |
| Mean..        | 79.1          | 43.0          | 61.1          | .....                     | .....                    | .....                       | .....          | 42                          | .....                  | .....                       | .....                 | 5530                       | 7.6                                   |

Table 10—Year 1901

| Month.        | Temperature   |               |               |                           |                          |                             | Precipitation. | Relative Humidity per cent. | Sky                    |                             |                       | Wind                       |                                       |
|---------------|---------------|---------------|---------------|---------------------------|--------------------------|-----------------------------|----------------|-----------------------------|------------------------|-----------------------------|-----------------------|----------------------------|---------------------------------------|
|               | Mean Maximum. | Mean Minimum. | Monthly Mean. | Highest during the month. | Lowest during the month. | Number of days 32° or less. |                |                             | Number of days cloudy. | Number of days part cloudy. | Number of days clear. | Wind Movement total miles. | Wind Movement average miles per hour. |
| Jan....       | 61.3          | 26.5          | 43.4          | 73                        | 12                       | 23                          | 0.31           | 37                          | 9                      | 2                           | 20                    | 4965                       | 6.5                                   |
| Feb....       | 64.1          | 31.6          | 47.8          | 81                        | 20                       | 16                          | 0.95           | 45                          | 6                      | 6                           | 16                    | 4900                       | 7.3                                   |
| March..       | 68.9          | 31.8          | 50.4          | 84                        | 22                       | 21                          | 0.61           | 30                          | 4                      | 7                           | 20                    | 8021                       | 10.8                                  |
| April... 76.8 | 38.9          | 56.8          | 89            | 25                        | 11                       | 0                           | 0.30           | 25                          | 4                      | 10                          | 16                    | 6420                       | 8.9                                   |
| May....       | 87.2          | 50.0          | 68.6          | 96                        | 36                       | 0                           | T              | 27                          | 2                      | 6                           | 23                    | 7470                       | 10.0                                  |
| June....      | 94.8          | 56.5          | 75.6          | 104                       | 42                       | 0                           | 1.08           | 26                          | 4                      | 6                           | 20                    | 5800                       | 8.1                                   |
| July....      | 94.4          | 65.0          | 79.7          | 105                       | 57                       | 0                           | 2.23           | 45                          | 11                     | 6                           | 11                    | 6180                       | 8.3                                   |
| Aug....       | 90.6          | 63.1          | 79.8          | 102                       | 56                       | 0                           | 1.35           | 39                          | 9                      | 6                           | 16                    | 4785                       | 6.4                                   |
| Sept....      | 90.6          | 55.9          | 73.2          | 100                       | 43                       | 0                           | 1.25           | 41                          | 3                      | 7                           | 20                    | 5325                       | 7.7                                   |
| Oct....       | 75.9          | 45.7          | 60.8          | 91                        | 34                       | 4                           | 2.85           | 47                          | 9                      | 4                           | 18                    | 4460                       | 6.0                                   |
| Nov....       | 68.6          | 35.1          | 51.8          | 77                        | 27                       | 13                          | 0.98           | 47                          | 4                      | 7                           | 19                    | 3700                       | 5.1                                   |
| Dec....       | 61.6          | 23.9          | 42.8          | 74                        | 11                       | 25                          | 0.05           | 32                          | 4                      | 5                           | 22                    | 4615                       | 6.2                                   |
| Total..       | .....         | .....         | .....         | .....                     | .....                    | 103                         | 11.96          | .....                       | 72                     | 72                          | 221                   | .....                      | .....                                 |
| Mean..        | 78.4          | 43.5          | 60.9          | .....                     | .....                    | .....                       | .....          | 36                          | .....                  | .....                       | .....                 | 5500                       | 7.6                                   |

**Table 11—Year 1902**

| Month.        | Temperature   |               |               |                           |                          |                             | Precipitation. | Relative Humidity per cent. | Sky                    |                             |                       | Wind                       |                                      |
|---------------|---------------|---------------|---------------|---------------------------|--------------------------|-----------------------------|----------------|-----------------------------|------------------------|-----------------------------|-----------------------|----------------------------|--------------------------------------|
|               | Mean Maximum. | Mean Minimum. | Monthly Mean. | Highest during the month. | Lowest during the month. | Number of days 32° or less. |                |                             | Number of days cloudy. | Number of days part cloudy. | Number of days clear. | Wind Movement total miles. | Wind Movement average miles per hour |
| Jan....       | 61.3          | 24.9          | 43.0          | 68                        | 14                       | 23                          | 12             | 0.02                        | 7                      | 4                           | 20                    | 4800                       | 6.4                                  |
| Feb....       | 66.2          | 26.8          | 46.5          | 78                        | 16                       | 21                          | 3              | 0.05                        | 3                      | 5                           | 21                    | 6120                       | 9.1                                  |
| March..       | 68.0          | 32.0          | 50.0          | 78                        | 16                       | 16                          | 2              | 0.05                        | 5                      | 7                           | 22                    | 8355                       | 11.2                                 |
| April... 83.9 | 40.7          | 62.3          | 52            | 92                        | 28                       | 2                           | 0              | 0.00                        | 15                     | 5                           | 24                    | 6390                       | 8.9                                  |
| May.... 88.4  | 48.5          | 68.4          | 58            | 99                        | 37                       | 0                           | 0              | 0.01                        | 19                     | 12                          | 17                    | 5520                       | 7.4                                  |
| June.... 88.7 | 57.2          | 73.0          | 65            | 106                       | 44                       | 0                           | 0              | 0.07                        | 17                     | 20                          | 28                    | 5800                       | 7.4                                  |
| July.... 91.5 | 63.9          | 77.2          | 70            | 103                       | 54                       | 0                           | 0              | 2.16                        | 44                     | 10                          | 15                    | 6070                       | 8.1                                  |
| August.. 90.7 | 62.6          | 76.6          | 69            | 102                       | 59                       | 0                           | 0              | 5.77                        | 51                     | 3                           | 19                    | 4650                       | 6.2                                  |
| Sept.... 84.5 | 54.3          | 69.4          | 64            | 94                        | 42                       | 0                           | 0              | 1.23                        | 51                     | 2                           | 18                    | 4680                       | 6.5                                  |
| Oct.... 81.3  | 40.3          | 60.8          | 54            | 87                        | 30                       | 1                           | 0              | 0.00                        | 31                     | 3                           | 27                    | 4500                       | 6.0                                  |
| Nov.... 67.4  | 30.6          | 49.0          | 40            | 80                        | 13                       | 16                          | 6              | 0.61                        | 40                     | 4                           | 19                    | 4375                       | 6.1                                  |
| Dec.... 57.2  | 27.4          | 42.3          | 38            | 70                        | 16                       | 26                          | 17             | 0.99                        | 53                     | 7                           | 21                    | 5635                       | 7.4                                  |
| Total..       | .....         | .....         | .....         | .....                     | .....                    | 108                         | 40             | 10.90                       | .....                  | 49                          | 66                    | 5525                       | .....                                |
| Mean..        | 78.3          | 42.3          | 60.3          | .....                     | .....                    | .....                       | .....          | .....                       | 34                     | .....                       | .....                 | 5525                       | 7.6                                  |

**Table 12—Year 1903**

| Month.        | Temperature   |               |               |                           |                          |                             | Precipitation. | Relative Humidity per cent. | Sky                    |                             |                       | Wind                       |                                       |
|---------------|---------------|---------------|---------------|---------------------------|--------------------------|-----------------------------|----------------|-----------------------------|------------------------|-----------------------------|-----------------------|----------------------------|---------------------------------------|
|               | Mean Maximum. | Mean Minimum. | Monthly Mean. | Highest during the month. | Lowest during the month. | Number of days 32° or less. |                |                             | Number of days cloudy. | Number of days part cloudy. | Number of days clear. | Wind Movement total miles. | Wind Movement average miles per hour. |
| Jan....       | 52.7          | 24.8          | 41.8          | 71                        | 12                       | 26                          | 18             | 0.20                        | 47                     | 3                           | 11                    | 5000                       | 6.7                                   |
| Feb....       | 56.7          | 25.2          | 41.0          | 73                        | 9                        | 21                          | 18             | 0.98                        | 50                     | 6                           | 14                    | 5800                       | 8.6                                   |
| March..       | 68.4          | 30.7          | 49.6          | 83                        | 17                       | 21                          | 3              | 0.37                        | 33                     | 6                           | 19                    | 6175                       | 8.7                                   |
| April... 77.6 | 43.5          | 60.5          | 52            | 89                        | 34                       | 0                           | 0              | 0.08                        | 23                     | 1                           | 23                    | 7915                       | 11.0                                  |
| May.... 83.8  | 46.6          | 65.2          | 56            | 90                        | 35                       | 0                           | 0              | 0.10                        | 25                     | 5                           | 24                    | 7000                       | 9.4                                   |
| June.... 88.6 | 55.8          | 72.2          | 64            | 103                       | 45                       | 0                           | 0              | 3.65                        | 39                     | 5                           | 4                     | 5100                       | 7.1                                   |
| July.... 96.6 | 63.7          | 80.2          | 72            | 101                       | 52                       | 0                           | 0              | 0.97                        | 30                     | 0                           | 7                     | 5520                       | 7.4                                   |
| Aug.... 92.0  | 63.6          | 78.0          | 70            | 100                       | 55                       | 0                           | 0              | 1.50                        | 41                     | 3                           | 16                    | 5100                       | 6.8                                   |
| Sept.... 86.1 | 53.7          | 70.9          | 62            | 97                        | 42                       | 0                           | 0              | 2.43                        | 43                     | 3                           | 6                     | 5200                       | 7.2                                   |
| Oct.... 78.3  | 37.6          | 58.0          | 48            | 88                        | 29                       | 2                           | 0              | 0.00                        | 32                     | 0                           | 31                    | 4270                       | 5.7                                   |
| Nov.... 72.0  | 28.0          | 50.0          | 41            | 81                        | 17                       | 25                          | 2              | 0.00                        | 24                     | 0                           | 22                    | 3870                       | 5.4                                   |
| Dec.... 59.4  | 22.4          | 40.9          | 32            | 72                        | 14                       | 29                          | 17             | 0.01                        | 28                     | 4                           | 23                    | 4450                       | 6.0                                   |
| Total..       | .....         | .....         | .....         | .....                     | .....                    | 130                         | 58             | 10.29                       | .....                  | 35                          | 73                    | 5475                       | .....                                 |
| Mean..        | 76.5          | 41.5          | 59.0          | .....                     | .....                    | .....                       | .....          | .....                       | 31                     | .....                       | .....                 | 5475                       | 7.5                                   |

Table 13—Year 1904

| Month.    | Temperature   |               |               |                           |                          |                             | Precipitation. | Relative Humidity per cent. | Sky                         |                        |                             | Wind.                 |                            |                                       |
|-----------|---------------|---------------|---------------|---------------------------|--------------------------|-----------------------------|----------------|-----------------------------|-----------------------------|------------------------|-----------------------------|-----------------------|----------------------------|---------------------------------------|
|           | Mean Maximum. | Mean Minimum. | Monthly Mean. | Highest during the month. | Lowest during the month. | Number of days 25° or less. |                |                             | Number of days 60° or less. | Number of days cloudy. | Number of days part cloudy. | Number of days clear. | Wind movement total miles. | Wind movement average miles per hour. |
| Jan.....  | 58.2          | 17.6          | 37.9          | 71                        | 4                        | 30                          | 19             | T                           | 23                          | 1                      | 1                           | 29                    | 5125                       | 6.9                                   |
| Feb.....  | 68.8          | 27.2          | 48.0          | 86                        | 10                       | 21                          | 5              | 0.11                        | 25                          | 1                      | 3                           | 25                    | 5110                       | 7.3                                   |
| March.... | 74.3          | 34.7          | 54.5          | 84                        | 23                       | 15                          | 1              | 0.00                        | 13                          | 1                      | 4                           | 26                    | 7475                       | 10.0                                  |
| April.... | 81.0          | 40.7          | 60.8          | 91                        | 29                       | 4                           | 0              | 0.00                        | 13                          | 0                      | 3                           | 27                    | 7120                       | 9.9                                   |
| May.....  | 86.2          | 49.9          | 68.1          | 96                        | 30                       | 1                           | 0              | 0.05                        | 18                          | 0                      | 4                           | 27                    | 7100                       | 9.5                                   |
| June....  | 93.8          | 60.4          | 77.1          | 100                       | 48                       | 0                           | 0              | 0.70                        | 25                          | 0                      | 3                           | 27                    | 7110                       | 9.9                                   |
| July..... | 94.8          | 64.5          | 79.6          | 101                       | 56                       | 0                           | 0              | 1.36                        | 23                          | 3                      | 3                           | 25                    | 6760                       | 9.1                                   |
| August... | 91.7          | 63.1          | 77.4          | 98                        | 58                       | 0                           | 0              | 1.24                        | 43                          | 4                      | 6                           | 21                    | 5320                       | 7.1                                   |
| Sept....  | 83.5          | 57.8          | 70.6          | 97                        | 52                       | 0                           | 0              | 4.02                        | 58                          | 9                      | 5                           | 16                    | 5120                       | 7.1                                   |
| Oct.....  | 73.6          | 47.0          | 60.3          | 88                        | 30                       | 4                           | 3              | 1.52                        | 56                          | 6                      | 5                           | 20                    | 5100                       | 6.8                                   |
| Nov.....  | 66.5          | 28.8          | 47.6          | 74                        | 17                       | 25                          | 3              | 0.50                        | 44                          | 1                      | 2                           | 27                    | 3515                       | 4.9                                   |
| Dec.....  | 58.2          | 25.8          | 42.9          | 73                        | 16                       | 27                          | 18             | 0.63                        | 49                          | 7                      | 1                           | 23                    | 4210                       | 5.6                                   |
| Total..   | .....         | .....         | .....         | .....                     | .....                    | 127                         | 49             | 10.13                       | .....                       | 33                     | 40                          | 293                   | .....                      | .....                                 |
| Mean..    | 77.5          | 43.1          | 60.3          | .....                     | .....                    | .....                       | .....          | 83                          | .....                       | .....                  | .....                       | .....                 | 5755                       | 7.9                                   |

Table 14—Year 1905

| Month.    | Temperature. |               |               |                           |                          |                             | Precipitation. | Relative Humidity per cent. | Sky                         |                        |                              | Wind                  |                            |                                       |
|-----------|--------------|---------------|---------------|---------------------------|--------------------------|-----------------------------|----------------|-----------------------------|-----------------------------|------------------------|------------------------------|-----------------------|----------------------------|---------------------------------------|
|           | Mean Maximum | Mean Minimum. | Monthly Mean. | Highest during the month. | Lowest during the month. | Number of days 32° or less. |                |                             | Number of days 60° or less. | Number of days cloudy. | Number of days part cloudy.. | Number of days clear. | Wind movement total miles. | Wind movement average miles per hour. |
| Jan....   | 59.7         | 27.8          | 43.8          | 72                        | 16                       | 25                          | 19             | 1.01                        | 51                          | 5                      | 24                           | 4400                  | 5.9                        |                                       |
| Feb....   | 57.9         | 34.2          | 46.0          | 73                        | 18                       | 11                          | 17             | 1.26                        | 61                          | 13                     | 9                            | 4540                  | 6.8                        |                                       |
| March...  | 66.5         | 39.7          | 53.1          | 83                        | 26                       | 2                           | 5              | 2.03                        | 74                          | 8                      | 16                           | 5950                  | 8.0                        |                                       |
| April.... | 72.6         | 41.5          | 57.0          | 82                        | 31                       | 2                           | 2              | 1.89                        | 44                          | 5                      | 24                           | 6375                  | 8.8                        |                                       |
| May....   | 84.9         | 46.2          | 65.6          | 94                        | 39                       | 0                           | 0              | 0.06                        | 23                          | 0                      | 27                           | 6740                  | 9.1                        |                                       |
| June....  | 94.9         | 60.8          | 77.8          | 103                       | 51                       | 0                           | 0              | 0.58                        | 38                          | 2                      | 23                           | 5110                  | 7.1                        |                                       |
| July....  | 94.0         | 61.3          | 77.6          | 105                       | 51                       | 0                           | 0              | 1.83                        | 38                          | 3                      | 25                           | 5620                  | 7.6                        |                                       |
| August... | 91.5         | 63.5          | 79.0          | 100                       | 58                       | 0                           | 0              | 1.58                        | 44                          | 1                      | 24                           | 4395                  | 6.0                        |                                       |
| Sept....  | 85.6         | 58.8          | 72.7          | 99                        | 43                       | 0                           | 0              | 3.06                        | 49                          | 7                      | 22                           | 4790                  | 6.6                        |                                       |
| Oct....   | 76.2         | 44.8          | 60.5          | 89                        | 30                       | 3                           | 3              | 0.83                        | 51                          | 4                      | 22                           | 4860                  | 6.5                        |                                       |
| Nov....   | 63.6         | 39.4          | 51.5          | 74                        | 24                       | 7                           | 9              | 2.14                        | 63                          | 13                     | 15                           | 4895                  | 6.8                        |                                       |
| Dec....   | 51.8         | 24.0          | 37.9          | 60                        | 10                       | 28                          | 31             | 0.81                        | 48                          | 5                      | 21                           | 5115                  | 6.9                        |                                       |
| Total..   | .....        | .....         | .....         | .....                     | .....                    | 78                          | 83             | 17.10                       | .....                       | 60                     | 44                           | 252                   | .....                      | .....                                 |
| Mean..    | 75.3         | 45.2          | 60.2          | .....                     | .....                    | .....                       | .....          | 47                          | .....                       | .....                  | .....                        | 5230                  | 7.2                        |                                       |

Table 15—Mean Maximum Temperatures

| Year. | Jan. | Feb. | March | April | May  | June | July | August | Sept. | Oct. | Nov. | Dec. | Annual mean. |
|-------|------|------|-------|-------|------|------|------|--------|-------|------|------|------|--------------|
| 1882  | 55.6 | 61.4 | 66.9  | 70.5  | 82.8 | 95.2 | 96.0 | 92.4   | 90.2  | 76.6 | 63.8 | 55.0 | 76.1         |
| 1883  | 51.4 | 60.1 | 67.7  | 78.9  | 83.4 | 97.5 | 93.8 | 88.0   | 86.0  | 77.9 | 66.4 | 61.9 | 78.9         |
| 1884  | 55.9 | 56.5 | 68.0  | 78.8  | 86.8 | 98.4 | 95.4 | 90.2   | 88.0  | 81.0 | 72.7 | 58.3 | 77.1         |
| 1885  | 58.3 | 57.4 | 69.7  | 78.4  | 84.1 | 91.0 | 90.8 | 89.3   | 87.1  | 73.8 | 62.7 | 55.6 | 74.6         |
| 1886  | 50.5 | 60.2 | 71.4  | 77.3  | 84.0 | 96.2 | 89.7 | 82.3   | 85.7  | 73.2 | 68.9 | 63.0 | 77.3         |
| 1887  | 54.3 | 62.8 | 68.5  | 79.2  | 86.4 | 92.6 | 90.7 | 89.7   | 88.0  | 75.6 | 71.2 | 58.9 | 76.0         |
| 1888  | 54.5 | 67.4 | 67.2  | 77.4  | 82.5 | 89.5 | 90.4 | 91.1   | 87.7  | 80.6 | 67.0 | 50.0 | 75.2         |
| 1889  | 55.2 | 60.5 | 72.3  | 76.7  | 84.7 | 91.4 | 92.9 | 93.8   | 90.0  | 78.2 | 69.1 | 57.7 | 77.1         |
| 1890  | 62.5 | 63.9 | 73.8  | 72.4  | 88.2 | 96.3 | 95.6 | 95.7   | 89.2  | 79.8 | 70.0 | 60.5 | 79.1         |
| 1901  | 61.3 | 64.1 | 68.9  | 76.8  | 87.2 | 94.8 | 94.4 | 95.6   | 90.6  | 75.9 | 68.6 | 61.6 | 78.4         |
| 1902  | 61.2 | 66.2 | 68.0  | 83.9  | 88.4 | 98.7 | 91.5 | 90.7   | 84.5  | 81.3 | 67.4 | 57.2 | 78.3         |
| 1903  | 58.7 | 56.7 | 68.4  | 77.6  | 83.8 | 88.6 | 96.6 | 92.0   | 86.1  | 78.3 | 72.0 | 59.4 | 76.5         |
| 1904  | 58.2 | 68.8 | 74.3  | 81.0  | 86.2 | 93.8 | 94.8 | 91.7   | 83.5  | 73.6 | 66.3 | 58.2 | 77.6         |
| 1905  | 59.7 | 57.9 | 66.5  | 72.6  | 84.9 | 94.9 | 94.0 | 94.5   | 86.6  | 76.2 | 63.6 | 51.8 | 75.3         |
| Mean  | 58.5 | 61.7 | 69.3  | 77.7  | 85.5 | 94.0 | 93.8 | 92.1   | 87.1  | 77.2 | 67.8 | 57.8 | 76.8         |

Table 16—Mean Minimum Temperatures

| Year. | Jan. | Feb. | March. | April. | May.  | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. | Annual Mean |
|-------|------|------|--------|--------|-------|-------|-------|------|-------|------|------|------|-------------|
| 1882  | 28.0 | 30.9 | 34.6   | .....  | ..... | ..... | ..... | 61.5 | 50.9  | 39.8 | 30.6 | 26.1 | .....       |
| 1883  | 25.5 | 30.8 | 33.6   | 38.3   | 48.2  | 56.9  | 63.6  | 62.0 | 51.4  | 35.6 | 23.5 | 23.5 | 41.1        |
| 1884  | 18.5 | 25.5 | 30.4   | 40.4   | 46.6  | 51.7  | 59.7  | 60.8 | 50.6  | 43.4 | 25.3 | 31.0 | 40.1        |
| 1885  | 24.9 | 24.1 | 31.7   | 40.1   | 46.2  | 54.2  | 61.4  | 59.8 | 53.6  | 38.7 | 24.3 | 19.3 | 40.2        |
| 1886  | 22.4 | 23.6 | 30.1   | 35.2   | 46.2  | 57.2  | 62.7  | 59.1 | 55.7  | 44.1 | 30.6 | 22.4 | 40.8        |
| 1887  | 23.9 | 21.3 | 31.7   | 37.1   | 70.0  | 55.9  | 61.6  | 60.0 | 53.4  | 40.5 | 29.0 | 18.8 | 40.6        |
| 1888  | 19.7 | 26.1 | 31.4   | 43.3   | 42.9  | 54.8  | 61.2  | 59.6 | 48.9  | 32.8 | 25.0 | 20.7 | 38.9        |
| 1889  | 19.6 | 20.2 | 29.4   | 36.7   | 40.2  | 52.1  | 60.2  | 57.3 | 47.6  | 39.7 | 32.1 | 25.2 | 38.4        |
| 1890  | 26.8 | 28.8 | 37.1   | 36.3   | 50.1  | 58.6  | 64.8  | 60.4 | 59.0  | 43.7 | 29.4 | 21.3 | 43.0        |
| 1901  | 26.5 | 31.6 | 31.8   | 36.9   | 50.0  | 56.5  | 66.0  | 63.1 | 55.9  | 45.7 | 35.1 | 23.9 | 48.5        |
| 1902  | 24.9 | 26.8 | 32.0   | 40.7   | 48.5  | 57.2  | 62.9  | 62.6 | 51.3  | 40.3 | 30.6 | 27.4 | 42.3        |
| 1903  | 21.8 | 25.2 | 30.7   | 43.5   | 46.6  | 55.8  | 63.7  | 63.6 | 55.7  | 37.6 | 28.0 | 22.4 | 41.5        |
| 1904  | 17.6 | 27.2 | 34.7   | 40.7   | 49.9  | 60.4  | 64.5  | 63.1 | 57.8  | 47.0 | 28.4 | 25.8 | 43.1        |
| 1905  | 27.8 | 34.2 | 39.7   | 41.5   | 48.2  | 60.8  | 61.3  | 63.5 | 58.8  | 44.8 | 39.4 | 24.0 | 46.2        |
| Mean  | 23.2 | 26.9 | 32.8   | 39.3   | 46.9  | 56.4  | 62.5  | 61.2 | 54.2  | 41.0 | 29.7 | 23.7 | 41.4        |

## 36 FORTY YEARS OF SOUTHERN NEW MEXICO CLIMATE

Table 17—Mean Monthly and Annual Temperatures

| Year. | Jan. | Feb. | March   | April  | May  | June | July | August | Sept. | Oct. | Nov. | Dec. | Annual mean. |
|-------|------|------|---------|--------|------|------|------|--------|-------|------|------|------|--------------|
| 1851* |      |      |         |        |      |      |      |        | 79.6  | 63.2 | 48.2 | 44.1 |              |
| 1852  | 39.7 | 49.7 | 48.4    | 56.5   | 68.7 | 78.0 | 79.6 | 78.4   | 74.3  | 59.0 | 46.0 | 44.1 | 60.0         |
| 1853  | 41.7 | 45.0 | 52.7    | 65.5   | 72.5 | 81.8 | 85.4 | 81.4   | 77.5  | 65.0 | 57.5 | 50.8 | 64.7         |
| 1854  | 48.6 | 50.4 | 59.7    | 66.1   | 68.6 | 80.6 | 85.1 | 81.2   | 77.4  | 70.4 | 53.2 | 46.7 | 65.7         |
| 1856  | 50.1 | 50.6 | 55.4    | 64.4   | 75.4 | 82.2 | 83.4 | 82.5   | 77.2  | 65.6 | 53.4 | 47.0 | 65.7         |
| 1856  | 43.3 | 46.8 | 57.4    | 69.0   | 75.4 | 85.0 | 85.0 | 83.5   | 75.5  | 65.6 | 53.5 | 41.3 | 65.1         |
| 1857  | 46.7 | 49.2 | 61.3    | 63.9   | 75.4 | 81.3 | 84.8 | 81.8   | 73.1  | 61.1 | 54.9 | 41.4 | 65.0         |
| 1858  | 40.0 | 46.4 | 53.4    | 65.8   | 70.7 | 80.8 | 82.7 | 80.8   | 76.6  | 66.3 | 47.6 | 40.0 | 62.7         |
| 1859  | 35.1 | 51.0 | 52.3    | 63.1   | 76.8 | 85.9 | 78.1 | 83.9   | 74.9  | 66.2 | 40.8 | 33.9 | 61.8         |
| 1860  | 44.9 | 47.4 | 58.4    | 68.3   | 66.4 | 74.6 | 80.0 | 81.7   | 75.0  | 71.2 | 56.1 | 45.7 | 63.3         |
| 1861  | 44.4 | 43.2 | 54.4    | 63.8   | 70.4 |      |      |        |       |      |      |      |              |
| 1865† |      |      |         |        |      |      |      |        |       |      | 51.4 | 42.3 |              |
| 1866  | 45.4 |      | 56.2    |        |      |      |      |        | 74.8  | 64.1 | 49.8 | 43.0 |              |
| 1867  | 46.3 | 47.4 | 53.0    | 65.4   | 71.9 | 83.7 | 85.0 | 83.2   | 77.8  | 67.9 | 53.6 | 54.3 | 66.0         |
| 1868  | 44.9 | 50.6 | 57.0    | 63.4   | 70.5 | 82.8 | 81.6 | 80.1   | 74.4  | 64.1 | 49.7 | 42.9 | 63.5         |
| 1869  | 41.8 | 46.2 | 57.1    | 61.1   | 72.4 | 79.4 | 84.2 | 81.3   | 76.2  | 61.9 | 56.7 | 40.1 | 63.4         |
| 1870  | 42.1 | 48.0 | 54.0    | 64.3   | 73.6 | 80.2 | 79.5 | 76.5   | 70.6  | 59.8 | 48.2 | 35.9 | 61.1         |
| 1871  | 38.4 | 44.6 | 54.0    | 60.9   | 72.7 | 85.4 | 83.8 | 82.3   | 74.2  | 59.5 | 46.4 | 44.1 | 62.3         |
| 1872  | 37.3 | 47.6 | 53.7    | 62.0   | 74.4 | 81.7 | 80.8 | 78.7   | 71.7  | 59.6 | 44.2 | 45.6 | 61.4         |
| 1873  | 41.1 | 45.7 | 58.4    | 58.7   | 78.0 | 78.9 | 83.0 | 77.6   | 75.9  | 63.4 | 50.8 | 42.2 | 62.7         |
| 1874  | 45.9 | 44.6 | 53.3    | 56.1   | 72.0 | 84.8 | 84.4 | 84.3   | 73.7  | 61.7 | 52.3 | 40.5 | 63.0         |
| 1875  | 47.0 | 45.6 | 50.4    | 60.5   | 74.2 | 88.1 | 80.4 | 80.2   | 71.0  | 64.0 | 53.3 | 45.3 | 62.8         |
| 1876  | 48.5 | 46.9 | 52.4    | 62.4   | 71.6 | 81.1 | 83.2 | 80.5   | 72.8  | 60.9 | 49.5 | 40.6 | 62.1         |
| 1877  | 45.7 | 47.4 |         |        |      |      |      |        |       |      |      |      |              |
| 1877‡ |      |      |         |        |      |      |      | 80.2   | 73.8  | 60.2 | 46.7 | 42.2 |              |
| 1878  | 39.0 | 45.4 | 52.6    | 57.6   | 68.1 | 76.1 | 79.6 | 79.2   | 71.0  | 61.5 | 42.2 | 39.2 | 56.8         |
| 1879  | 40.9 | 50.4 | 59.7    | 59.7   | 71.8 | 77.1 | 80.4 | 76.4   | 75.1  | 62.1 | 48.4 | 44.5 | 62.2         |
| 1880  | 45.7 | 38.2 | 51.8    | 59.8   | 70.2 | 78.3 | 77.9 | 75.1   | 69.3  | 58.3 | 44.3 | 42.2 | 59.7         |
| 1881  | 37.7 | 47.6 | 50.5    | 61.4   | 70.0 | 79.6 | 79.5 | 76.5   | 69.5  | 63.7 | 45.6 | 44.5 | 60.7         |
| 1882  | 42.2 | 45.7 | 53.1    | 58.3   | 65.7 | 75.3 | 80.4 |        |       |      |      |      |              |
| 1886‡ | 41.6 | 47.6 | 51.4    | 62.9   | 77.0 | 80.5 | 83.6 | 79.9   | 70.4  | 60.8 | 45.1 | 44.6 | 62.1         |
| 1887  | 43.1 | 46.8 | 57.1    | 62.0   | 71.3 | 81.9 | 81.7 | 79.6   | 74.2  | 61.8 | 49.8 | 40.4 | 62.5         |
| 1888  | 42.1 | 47.2 | 53.9    | 66.2   | 71.9 | 83.2 | 82.8 | 80.3   | 72.9  | 63.3 | 49.7 | 44.4 | 63.2         |
| 1889  | 42.7 | 48.2 | (54.0)§ | (66.0) | 67.9 | 76.2 | 83.6 | 81.9   | 70.2  | 62.0 | 45.8 | 49.7 | (62.4)       |
| 1890  | 44.2 | 49.2 | (54.4)§ | 61.3   | 72.6 | 77.4 | 83.0 | 79.6   | 73.4  |      |      |      |              |
| 1892‡ | 39.3 | 46.1 | 50.7    |        |      |      |      | 76.9   | 70.5  | 58.2 | 47.2 | 40.5 |              |
| 1893  | 43.4 | 45.4 | 50.6    | 58.6   | 64.8 | 77.2 | 78.4 | 75.0   | 70.2  | 56.7 | 44.9 | 42.7 | 59.0         |
| 1894  | 37.2 | 39.5 | 49.2    | 59.6   | 66.7 | 72.5 | 77.5 | 75.4   | 69.3  | 62.2 | 49.0 | 44.7 | 58.6         |
| 1895  | 40.6 | 40.7 | 50.7    | 59.2   | 65.1 | 72.6 | 76.1 | 74.5   | 70.3  | 56.0 | 45.5 | 37.4 | 57.4         |
| 1896  | 41.4 | 41.9 | 50.7    | 59.2   | 67.1 | 76.7 | 76.2 | 75.7   | 71.2  | 58.6 | 49.7 | 42.7 | 59.0         |
| 1897  | 39.1 | 43.5 | 50.1    | 59.1   | 68.2 | 74.2 | 76.1 | 74.8   | 69.2  | 58.0 | 50.1 | 38.8 | 58.3         |
| 1898  | 37.1 | 46.7 | 49.3    | 60.3   | 62.7 | 72.2 | 75.8 | 75.4   | 68.3  | 56.7 | 46.0 | 35.4 | 57.1         |
| 1899  | 38.9 | 40.3 | 50.8    | 56.7   | 62.4 | 72.2 | 76.6 | 75.6   | 68.8  | 59.9 | 50.6 | 41.4 | 57.8         |
| 1900  | 44.6 | 46.4 | 55.0    | 54.4   | 69.2 | 78.4 | 80.2 | 78.2   | 74.1  | 61.8 | 49.7 | 40.9 | 61.1         |
| 1901  | 43.4 | 47.8 | 50.4    | 56.8   | 68.6 | 75.6 | 79.7 | 79.8   | 73.2  | 60.8 | 51.8 | 42.8 | 60.9         |
| 1902  | 43.0 | 46.5 | 50.0    | 62.3   | 68.4 | 78.0 | 77.2 | 76.6   | 69.4  | 60.8 | 49.0 | 42.3 | 60.3         |
| 1903  | 41.2 | 41.0 | 49.6    | 60.5   | 65.2 | 72.2 | 80.2 | 78.0   | 70.9  | 58.0 | 50.0 | 40.9 | 59.0         |
| 1904  | 37.9 | 48.0 | 54.5    | 60.8   | 68.1 | 77.1 | 79.6 | 77.4   | 70.6  | 60.3 | 47.6 | 42.0 | 60.3         |
| 1905  | 43.8 | 46.0 | 53.1    | 57.0   | 65.6 | 77.8 | 77.6 | 79.0   | 72.7  | 60.5 | 51.5 | 37.9 | 60.3         |
| Mean  | 42.2 | 46.4 | 53.5    | 61.2   | 70.3 | 78.9 | 80.8 | 79.4   | 73.0  | 62.0 | 49.5 | 42.5 | 61.6         |

\* Records taken at Fort Fillmore from 1851 to 1861.

† Records taken at Fort Selden from 1865 to 1877.

‡ Records taken at Mesilla from 1877 to 1882.

§ Records taken at Fort Selden from 1886 to 1890.

¶ Records taken at Agricultural College from 1892 to 1905.

§ Interpolated values enclosed in brackets.



Table 18—Highest Temperature During the Month

| Year. | Jan. | Feb. | March. | April. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. | Annual. |
|-------|------|------|--------|--------|------|-------|-------|------|-------|------|------|------|---------|
| 1892  | 71   | 73   | 78     | 89     | 95   | 105   | 104   | 98   | 96    | 87   | 78   | 74   | .....   |
| 1893  | 73   | 71   | 87     | 91     | 93   | 105   | 103   | 96   | 95    | 87   | 81   | 77   | .....   |
| 1894  | 71   | 71   | 85     | 89     | 95   | 102   | 103   | 99   | 94    | 91   | 82   | 70   | .....   |
| 1895  | 66   | 75   | 82     | 88     | 98   | 99    | 102   | 94   | 96    | 82   | 73   | 68   | .....   |
| 1896  | 71   | 75   | 89     | 87     | 101  | 104   | 98    | 99   | 96    | 88   | 78   | 70   | .....   |
| 1897  | 68   | 77   | 79     | 88     | 93   | 101   | 98    | 98   | 90    | 86   | 82   | 68   | .....   |
| 1898  | 68   | 78   | 77     | 90     | 92   | 100   | 102   | 97   | 95    | 91   | 81   | 68   | .....   |
| 1899  | 69   | 76   | 86     | 87     | 95   | 98    | 101   | 99   | 101   | 90   | 82   | 75   | .....   |
| 1900  | 71   | 78   | 86     | 83     | 98   | 108   | 103   | 102  | 97    | 91   | 80   | 70   | .....   |
| 1901  | 73   | 81   | 84     | 89     | 98   | 104   | 105   | 102  | 100   | 91   | 77   | 74   | .....   |
| 1902  | 68   | 78   | 76     | 92     | 99   | 108   | 103   | 102  | 94    | 87   | 80   | 70   | .....   |
| 1903  | 71   | 73   | 83     | 89     | 90   | 103   | 101   | 100  | 97    | 88   | 81   | 72   | .....   |
| 1904  | 71   | 86   | 84     | 91     | 96   | 100   | 101   | 96   | 97    | 88   | 74   | 73   | .....   |
| 1905  | 72   | 73   | 80     | 82     | 94   | 103   | 105   | 100  | 99    | 89   | 74   | 60   | .....   |
| Mean  | 70   | 76   | 82     | 88     | 95   | 102   | 102   | 99   | 96    | 88   | 78   | 71   | .....   |

Table 19—Lowest Temperature During the Month

| Year. | Jan. | Feb. | March. | April. | May.  | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. | Annual. |
|-------|------|------|--------|--------|-------|-------|-------|------|-------|------|------|------|---------|
| 1892  | 4    | 18   | 23     | .....  | ..... | ..... | ..... | 54   | 43    | 29   | 25   | 12   | .....   |
| 1893  | 10   | 14   | 21     | 20     | 33    | 46    | 56    | 51   | 39    | 27   | 15   | 9    | .....   |
| 1894  | 9    | 5    | 15     | 30     | 34    | 41    | 48    | 52   | 40    | 23   | 15   | 15   | .....   |
| 1895  | 13   | 5    | 19     | 28     | 34    | 37    | 56    | 53   | 35    | 28   | 19   | 11   | .....   |
| 1896  | 9    | 10   | 15     | 22     | 31    | 46    | 57    | 54   | 44    | 29   | 15   | 11   | .....   |
| 1897  | 9    | 16   | 15     | 21     | 30    | 43    | 51    | 50   | 45    | 26   | 20   | 9    | .....   |
| 1898  | 7    | 16   | 12     | 26     | 32    | 42    | 52    | 53   | 39    | 20   | 9    | 10   | .....   |
| 1899  | 8    | 2    | 15     | 25     | 27    | 36    | 55    | 51   | 36    | 27   | 20   | 16   | .....   |
| 1900  | 17   | 11   | 20     | 29     | 33    | 47    | 53    | 47   | 46    | 29   | 20   | 14   | .....   |
| 1901  | 12   | 20   | 22     | 25     | 36    | 42    | 57    | 55   | 43    | 34   | 27   | 11   | .....   |
| 1902  | 14   | 16   | 16     | 28     | 37    | 44    | 54    | 59   | 42    | 30   | 13   | 16   | .....   |
| 1903  | 12   | 9    | 17     | 34     | 35    | 45    | 52    | 55   | 42    | 29   | 17   | 14   | .....   |
| 1904  | 4    | 10   | 23     | 29     | 30    | 48    | 56    | 58   | 52    | 30   | 17   | 16   | .....   |
| 1905  | 16   | 18   | 26     | 31     | 38    | 51    | 51    | 58   | 43    | 30   | 24   | 10   | .....   |
| Mean  | 10   | 12   | 18     | 28     | 34    | 44    | 54    | 54   | 42    | 28   | 18   | 12   | .....   |

Table 20—Number of days 60° or less

| Year | Jan. | Feb. | March | April | May | June | July | August | Sept. | Oct. | Nov. | Dec. | Total Annual |
|------|------|------|-------|-------|-----|------|------|--------|-------|------|------|------|--------------|
| 1892 | 19   | 11   | 5     | 4     | 0   | 0    | 0    | 0      | 0     | 0    | 2    | 19   | 65           |
| 1893 | 18   | 13   | 7     | 0     | 0   | 0    | 0    | 0      | 0     | 0    | 2    | 11   | 55           |
| 1894 | 20   | 15   | 7     | 0     | 0   | 0    | 0    | 0      | 0     | 0    | 0    | 19   | 61           |
| 1895 | 16   | 12   | 2     | 2     | 0   | 0    | 0    | 0      | 1     | 0    | 2    | 12   | 58           |
| 1896 | 14   | 14   | 3     | 3     | 0   | 0    | 0    | 0      | 0     | 0    | 4    | 5    | 43           |
| 1897 | 23   | 11   | 5     | 3     | 0   | 0    | 0    | 0      | 0     | 5    | 2    | 17   | 67           |
| 1898 | 21   | 5    | 5     | 0     | 0   | 0    | 0    | 0      | 0     | 0    | 5    | 26   | 66           |
| 1899 | 20   | 12   | 0     | 0     | 0   | 0    | 0    | 0      | 0     | 0    | 5    | 18   | 55           |
| 1900 | 8    | 8    | 2     | 2     | 0   | 0    | 0    | 0      | 0     | 0    | 2    | 9    | 31           |
| 1901 | 14   | 10   | 2     | 2     | 0   | 0    | 0    | 0      | 0     | 4    | 3    | 14   | 49           |
| 1902 | 12   | 3    | 2     | 0     | 0   | 0    | 0    | 0      | 0     | 0    | 2    | 17   | 40           |
| 1903 | 18   | 18   | 3     | 0     | 0   | 0    | 0    | 0      | 0     | 0    | 2    | 17   | 58           |
| 1904 | 19   | 5    | 1     | 0     | 0   | 0    | 0    | 0      | 0     | 3    | 3    | 18   | 49           |
| 1905 | 19   | 17   | 5     | 2     | 0   | 0    | 0    | 0      | 0     | 0    | 0    | 31   | 83           |
| Mean | 17   | 11   | 4     | 1     | 0   | 0    | 0    | 0      | 0     | 1    | 5    | 17   | 56           |

Table 21—Number of days 32° or less

| Year | Jan. | Feb. | March | April | May | June | July | August | Sept. | Oct. | Nov. | Dec. | Total Annual |
|------|------|------|-------|-------|-----|------|------|--------|-------|------|------|------|--------------|
| 1892 | 27   | 18   | 11    | 3     | 0   | 0    | 0    | 0      | 0     | 6    | 21   | 28   | 112          |
| 1893 | 28   | 16   | 12    | 5     | 0   | 0    | 0    | 0      | 0     | 9    | 29   | 29   | 123          |
| 1894 | 30   | 24   | 19    | 5     | 0   | 0    | 0    | 0      | 0     | 6    | 29   | 16   | 129          |
| 1895 | 25   | 21   | 17    | 5     | 0   | 0    | 0    | 0      | 0     | 1    | 21   | 29   | 119          |
| 1896 | 26   | 24   | 18    | 10    | 2   | 0    | 0    | 0      | 0     | 1    | 19   | 29   | 129          |
| 1897 | 29   | 23   | 17    | 7     | 0   | 0    | 0    | 0      | 0     | 7    | 25   | 30   | 138          |
| 1898 | 29   | 24   | 15    | 2     | 1   | 0    | 0    | 0      | 0     | 14   | 23   | 30   | 138          |
| 1899 | 30   | 26   | 20    | 8     | 5   | 0    | 0    | 0      | 0     | 6    | 19   | 28   | 142          |
| 1900 | 25   | 19   | 5     | 6     | 0   | 0    | 0    | 0      | 0     | 2    | 20   | 30   | 107          |
| 1901 | 23   | 16   | 21    | 11    | 0   | 0    | 0    | 0      | 0     | 0    | 13   | 25   | 109          |
| 1902 | 26   | 21   | 16    | 2     | 0   | 0    | 0    | 0      | 0     | 1    | 16   | 26   | 108          |
| 1903 | 26   | 21   | 21    | 0     | 0   | 0    | 0    | 0      | 0     | 8    | 25   | 29   | 130          |
| 1904 | 30   | 21   | 15    | 4     | 1   | 0    | 0    | 0      | 0     | 4    | 27   | 27   | 127          |
| 1905 | 25   | 11   | 2     | 2     | 0   | 0    | 0    | 0      | 0     | 3    | 7    | 28   | 78           |
| Mean | 27   | 20   | 15    | 5     | 1   | 0    | 0    | 0      | 0     | 5    | 21   | 27   | 121          |

Table 22—Monthly and Annual Precipitations

| Year  | Jan.    | Feb. | March  | April | May  | June | July | August | Sept. | Oct. | Nov. | Dec. | Total Annual |
|-------|---------|------|--------|-------|------|------|------|--------|-------|------|------|------|--------------|
| 1851* |         |      |        |       |      |      |      |        | 1.40  | 0.11 | 2.13 | 1.74 | (12.63)      |
| 1852* | (0.23)† | 0.29 | 0.04   | 0.20  | 0.40 | 1.74 | 3.84 | 1.00   | 1.47  | 0.77 | 2.66 | 0.64 | 9.04         |
| 1853* | 0.04    | 0.10 | 0.03   | 0.01  | 0.06 | 0.28 | 2.80 | 1.83   | 1.21  | 0.90 | 1.15 | 0.60 | 6.07         |
| 1854  | 0.00    | 0.00 | 0.55   | 0.10  | 0.88 | 0.08 | 0.87 | 1.38   | 0.96  | 0.39 | 0.67 | 0.15 | 7.51         |
| 1855  | 0.00    | 0.00 | 0.12   | 0.45  | 0.10 | 0.07 | 2.63 | 1.29   | 2.31  | 0.09 | 0.45 | 0.00 | 9.22         |
| 1856  | 0.00    | 1.85 | 0.30   | 0.00  | 0.00 | 0.85 | 0.46 | 2.48   | 2.61  | 0.00 | 0.27 | 0.00 | 10.40        |
| 1857  | 0.30    | 0.95 | 0.00   | 0.28  | 0.00 | 0.00 | 0.43 | 3.68   | 2.24  | 2.41 | 0.00 | 0.13 | 5.11         |
| 1858  | 0.00    | 0.00 | 0.32   | 0.00  | 0.00 | 0.73 | 2.50 | 1.61   | 0.00  | 0.00 | 0.00 | 0.00 | 5.52         |
| 1859  | 0.00    | 0.14 | 0.00   | 0.00  | 0.00 | 0.00 | 1.18 | 1.15   | 1.59  | 0.80 | 1.16 | 0.00 | (3.61)       |
| 1860  | 0.06    | 1.10 | (0.15) | T     | 0.00 | 0.30 | 1.10 | T      | 0.20  | T    | T    | 0.00 |              |
| 1861  | 1.60    | T    | 0.00   | 0.00  |      |      |      |        |       |      |      |      |              |
| 1865† |         |      |        |       |      |      |      |        |       |      | 0.00 | 1.00 |              |
| 1866  | 0.00    |      | 0.81   |       |      |      |      |        | 0.73  |      | 0.69 | 0.17 | 9.89         |
| 1867  | 0.21    | 0.60 | 0.38   | 0.00  | 0.01 | 0.03 | 4.31 | 0.80   | 2.90  | 0.26 | 0.17 | 0.22 | 9.71         |
| 1868  | 0.67    | 0.02 | 0.06   | 0.12  | 1.13 | 0.01 | 2.00 | 1.79   | 1.68  | 0.34 | 0.33 | 1.50 | 12.50        |
| 1869  | 0.71    | 1.27 | 0.46   | 0.53  | 0.18 | 2.15 | 0.36 | 5.09   | 0.14  | 1.01 | 0.50 | 0.20 | 6.92         |
| 1870  | 0.00    | 0.00 | 0.00   | 0.00  | 0.00 | 1.70 | 5.20 | 4.06   | 0.70  | 0.65 | 0.00 | 0.25 | 6.33         |
| 1871  | 0.00    | 0.00 | 0.00   | 0.00  | 0.22 | 0.60 | 2.30 | 1.06   | 2.75  | 0.00 | 0.00 | 0.00 | 6.33         |
| 1872  | 0.15    | 0.00 | 0.00   | 0.00  | 0.00 | 0.09 | 1.19 | 0.85   | 1.10  | 0.25 | 0.00 | 2.70 | 3.49         |
| 1873  | 0.03    | 0.00 | 0.00   | 0.01  | 0.02 | 0.28 | 0.20 | 2.34   | 0.30  | 0.11 | 0.26 | 0.04 | 6.13         |
| 1874  | 0.59    | 0.55 | 0.26   | 0.62  | 0.01 | 0.18 | 0.39 | 1.10   | 0.55  | 0.62 | 0.71 | 0.75 | (5.02)       |
| 1875  | (0.33)  | T    | T      | T     | T    | 0.02 | 3.47 | 0.50   | 1.58  | 0.00 | T    | 0.12 | 9.76         |
| 1876  | 0.97    | 0.02 | 0.02   | 0.00  | 0.20 | 1.82 | 0.40 | 1.10   | 2.32  | 2.65 | 0.26 | 0.00 |              |
| 1877  | 0.01    | 4.46 |        |       |      |      |      |        |       |      |      |      |              |
| 1877‡ |         |      |        |       |      |      |      | 0.01   | 0.91  | 0.98 | 0.06 | 0.41 | 9.07         |
| 1878  | 0.07    | 0.43 | 0.69   | 0.15  | 1.38 | 1.02 | 2.06 | 0.61   | 0.21  | 0.09 | 1.29 | 0.07 | 7.30         |
| 1879  | 1.20    | 0.62 | 0.31   | 0.03  | 0.00 | 0.03 | 1.87 | 1.02   | 0.18  | 0.78 | 0.00 | 1.26 | 7.10         |
| 1880  | 0.14    | 0.43 | 0.52   | 0.45  | 0.00 | T    | 1.92 | 1.03   | 1.02  | 0.35 | 0.13 | 1.11 | 15.06        |
| 1881  | 0.04    | T    | 0.14   | 0.09  | 1.75 | 0.43 | 3.90 | 3.13   | 1.96  | 2.14 | 0.56 | 0.91 |              |
| 1882  | 0.63    | 1.36 | 0.41   | 0.01  | 0.10 | 0.72 | 1.32 |        |       |      |      |      |              |
| 1886‡ | T       | 0.10 | 0.00   | 0.00  | 0.00 | 0.62 | 0.00 | 1.05   | 3.25  | 2.27 | 0.60 | 0.00 | 7.89         |
| 1887  | 0.10    | 0.30 | 0.00   | 0.00  | 0.58 | 0.20 | 0.68 | 2.64   | 1.94  | 0.74 | 0.00 | 0.24 | 7.42         |
| 1888  | 0.16    | 1.15 | 0.82   | 0.54  | 0.00 | 0.00 | 1.28 | 0.76   | 0.67  | 2.52 | 2.71 | 0.48 | 11.06        |
| 1889  | 1.30    | 0.51 | 0.20   | 0.04  | 0.08 | 0.74 | 0.59 | 0.26   | 1.62  | 1.06 | 0.67 | 0.00 | 7.07         |
| 1890  | 0.73    | 0.00 | 0.02   | 0.04  | 0.00 | 0.29 | 0.84 | 2.63   | 1.84  |      |      |      |              |
| 1892§ | 0.67    | 0.36 | 0.46   | 0.06  | T    | 0.03 | 1.33 | 0.75   | 0.05  | 0.80 | 1.47 | 0.47 | 6.47         |
| 1893  | 0.07    | 1.23 | 0.02   | 0.00  | 0.77 | 0.40 | 2.04 | 4.19   | 2.39  | 0.03 | 0.03 | 0.02 | 10.82        |
| 1894  | 0.06    | 0.05 | 0.26   | 0.02  | T    | T    | 0.62 | 2.06   | 0.18  | 0.47 | 0.00 | 0.73 | 4.47         |
| 1895  | 0.45    | 0.60 | 0.01   | 0.00  | 0.52 | 0.10 | 3.03 | 3.19   | 0.96  | 1.20 | 0.45 | 0.32 | 9.83         |
| 1896  | 0.31    | 0.11 | 0.00   | 0.11  | 0.10 | 1.01 | 2.50 | 0.47   | 1.24  | 2.14 | 0.00 | T    | 7.99         |
| 1897  | 0.35    | 0.00 | 0.46   | 0.23  | 1.54 | 0.07 | 2.25 | 1.16   | 2.14  | 0.74 | T    | 0.03 | 8.98         |
| 1898  | 0.38    | 0.02 | 0.28   | 0.69  | T    | 1.83 | 2.18 | 2.43   | 1.74  | T    | 0.43 | 1.25 | 11.21        |
| 1899  | 0.05    | 0.09 | 0.19   | 0.13  | T    | 0.63 | 4.54 | 1.81   | 0.77  | 0.03 | 1.20 | 0.33 | 9.67         |
| 1900  | 0.32    | 0.42 | 1.36   | 0.31  | 0.88 | 0.16 | 1.52 | 0.90   | 1.80  | 0.45 | 0.23 | 0.01 | 8.40         |
| 1901  | 0.31    | 0.96 | 0.61   | 0.30  | T    | 1.06 | 2.23 | 3.35   | 2.85  | 0.08 | 0.05 | 0.05 | 11.96        |
| 1902  | 0.02    | T    | 0.05   | 0.00  | 0.01 | 0.07 | 2.16 | 5.77   | 1.22  | 0.70 | 0.61 | 0.99 | 10.90        |
| 1903  | 0.20    | 0.98 | 0.37   | 0.06  | 0.10 | 3.65 | 0.97 | 1.50   | 2.43  | 0.00 | 0.01 | 0.01 | 10.29        |
| 1904  | T       | 0.11 | 0.00   | 0.00  | 0.05 | 0.70 | 1.36 | 1.24   | 4.02  | 1.12 | 0.50 | 0.63 | 10.13        |
| 1905  | 1.01    | 1.26 | 2.03   | 1.49  | 0.06 | 0.54 | 1.83 | 1.58   | 3.06  | 0.83 | 2.14 | 0.81 | 17.10        |
| Mean  | .32     | .50  | .23    | .17   | .25  | .58  | 1.84 | 1.71   | 1.45  | .76  | .57  | .41  | 8.82         |

\* Records taken at Fort Fillmore from 1851 to 1861.

† Records taken at Fort Selden from 1865 to 1877.

‡ Records taken at Mesilla from 1877 to 1882.

§ Records taken at Fort Selden from 1886 to 1890.

¶ Records taken at Agricultural College from 1892 to 1905.

§ Interpolated values enclosed in brackets.

Table 23—Relative Humidity per cent.

| Year | Jan. | Feb. | March | April | May | June | July | August | Sept. | Oct. | Nov. | Dec. | Annual Mean |
|------|------|------|-------|-------|-----|------|------|--------|-------|------|------|------|-------------|
| 1892 | 58   | 50   | 68    | 60    | 56  | 49   | 55   | 67     | 56    | 65   | 74   | 71   | 61          |
| 1893 | 65   | 66   | 58    | 46    | 51  | 50   | 60   | 72     | 69    | 65   | 68   | 56   | 61          |
| 1894 | 56   | 56   | 54    | 49    | 52  | 48   | 48   | 62     | 58    | 60   | 66   | 66   | 56          |
| 1895 | 65   | 69   | 60    | 53    | 55  | 53   | 73   | 77     | 77    | 82   | 66   | 66   | 66          |
| 1896 | 68   | 65   | 52    | 55    | 44  | 48   | 72   | 68     | 70    | 80   | 66   | 60   | 60          |
| 1897 | 71   | 66   | 56    | 56    | 56  | 58   | 71   | 72     | 78    | 70   | 58   | 56   | 56          |
| 1898 | 62   | 57   | 54    | 54    | 51  | 50   | 65   | 65     | 62    | 50   | 49   | 57   | 57          |
| 1899 | 50   | 48   | 43    | 49    | 44  | 53   | 66   | 64     | 56    | 52   | 49   | 49   | 52          |
| 1900 | 53   | 41   | 44    | 40    | 32  | 37   | 49   | 44     | 49    | 42   | 32   | 28   | 42          |
| 1901 | 37   | 45   | 30    | 25    | 27  | 20   | 45   | 39     | 41    | 47   | 47   | 32   | 36          |
| 1902 | 32   | 27   | 22    | 15    | 19  | 17   | 44   | 51     | 51    | 31   | 40   | 53   | 34          |
| 1903 | 47   | 50   | 33    | 23    | 25  | 39   | 30   | 41     | 48    | 32   | 24   | 28   | 36          |
| 1904 | 23   | 25   | 13    | 13    | 13  | 25   | 33   | 43     | 58    | 56   | 41   | 49   | 33          |
| 1905 | 51   | 61   | 54    | 44    | 23  | 38   | 38   | 44     | 49    | 51   | 68   | 48   | 47          |
| Mean | 52   | 52   | 46    | 42    | 40  | 42   | 54   | 58     | 59    | 56   | 55   | 53   | 51          |

Table 24—Number of Days Cloudy

| Year | Jan. | Feb. | March | April | May | June | July | August | Sept. | Oct. | Nov. | Dec. | Total Annual |
|------|------|------|-------|-------|-----|------|------|--------|-------|------|------|------|--------------|
| 1892 | 7    | 4    | 6     | 4     | 0   | 0    | 0    | 3      | 2     | 0    | 2    | 2    | 27           |
| 1893 | 0    | 4    | 2     | 1     | 3   | 0    | 4    | 3      | 6     | 0    | 2    | 1    | 23           |
| 1894 | 2    | 5    | 5     | 0     | 0   | 0    | 0    | 0      | 0     | 0    | 0    | 9    | 17           |
| 1895 | 6    | 5    | 2     | 0     | 1   | 3    | 11   | 6      | 7     | 6    | 2    | 4    | 53           |
| 1896 | 6    | 4    | 9     | 4     | 5   | 5    | 11   | 5      | 5     | 6    | 2    | 6    | 53           |
| 1897 | 11   | 3    | 3     | 3     | 1   | 4    | 11   | 6      | 10    | 3    | 1    | 2    | 66           |
| 1898 | 8    | 3    | 8     | 4     | 3   | 2    | 12   | 9      | 7     | 0    | 3    | 6    | 66           |
| 1899 | 1    | 2    | 0     | 9     | 5   | 4    | 8    | 3      | 2     | 4    | 3    | 10   | 51           |
| 1900 | 4    | 6    | 8     | 3     | 4   | 5    | 11   | 6      | 7     | 5    | 6    | 5    | 71           |
| 1901 | 9    | 6    | 4     | 4     | 4   | 4    | 11   | 9      | 3     | 9    | 4    | 4    | 72           |
| 1902 | 7    | 2    | 2     | 1     | 2   | 0    | 6    | 3      | 9     | 2    | 7    | 4    | 46           |
| 1903 | 3    | 8    | 6     | 1     | 2   | 5    | 0    | 4      | 9     | 0    | 0    | 7    | 35           |
| 1904 | 1    | 1    | 1     | 0     | 0   | 0    | 3    | 4      | 9     | 6    | 1    | 7    | 33           |
| 1905 | 5    | 13   | 8     | 5     | 0   | 2    | 6    | 1      | 5     | 6    | 13   | 5    | 69           |
| Mean | 5    | 5    | 4     | 3     | 2   | 2    | 7    | 4      | 5     | 3    | 4    | 5    | 49           |

Table 25—Number of Days Part Cloudy

| Year | Jan. | Feb. | March | April | May | June | July | August | Sept. | Oct. | Nov. | Dec. | Total Annual |
|------|------|------|-------|-------|-----|------|------|--------|-------|------|------|------|--------------|
| 1892 | 6    | 0    | 0     | 4     | 10  | 5    | 14   | 17     | 2     | 9    | 5    | 11   | 83           |
| 1893 | 11   | 11   | 13    | 4     | 9   | 16   | 17   | 11     | 11    | 8    | 2    | 10   | 123          |
| 1894 | 9    | 12   | 15    | 6     | 12  | 7    | 12   | 25     | 15    | 8    | 2    | 15   | 158          |
| 1895 | 13   | 7    | 8     | 9     | 10  | 13   | 14   | 13     | 6     | 8    | 10   | 3    | 112          |
| 1896 | 10   | 14   | 8     | 11    | 9   | 9    | 15   | 16     | 14    | 13   | 8    | 8    | 136          |
| 1897 | 11   | 7    | 10    | 5     | 14  | 12   | 14   | 15     | 10    | 13   | 4    | 9    | 124          |
| 1898 | 7    | 7    | 7     | 11    | 9   | 12   | 15   | 13     | 5     | 7    | 6    | 7    | 108          |
| 1899 | 10   | 7    | 11    | 8     | 10  | 10   | 11   | 11     | 2     | 3    | 6    | 4    | 83           |
| 1900 | 7    | 3    | 4     | 10    | 6   | 7    | 4    | 8      | 3     | 3    | 2    | 3    | 66           |
| 1901 | 2    | 6    | 7     | 10    | 6   | 6    | 6    | 6      | 7     | 4    | 4    | 5    | 72           |
| 1902 | 4    | 7    | 7     | 5     | 12  | 2    | 10   | 8      | 3     | 2    | 4    | 3    | 65           |
| 1903 | 11   | 5    | 4     | 6     | 5   | 4    | 7    | 16     | 6     | 0    | 4    | 4    | 73           |
| 1904 | 1    | 3    | 4     | 3     | 4   | 3    | 3    | 6      | 5     | 5    | 2    | 1    | 40           |
| 1905 | 2    | 6    | 7     | 1     | 4   | 5    | 0    | 6      | 3     | 3    | 2    | 5    | 44           |
| Mean | 7    | 7    | 8     | 7     | 9   | 8    | 10   | 12     | 7     | 6    | 4    | 6    | 91           |

Table 26—Number of Days Clear

| Year | Jan. | Feb. | March | April | May | June | July | August | Sept. | Oct. | Nov. | Dec. | Total Annual |
|------|------|------|-------|-------|-----|------|------|--------|-------|------|------|------|--------------|
| 1892 | 18   | 25   | 25    | 22    | 21  | 25   | 17   | 14     | 26    | 22   | 23   | 18   | 256          |
| 1893 | 20   | 13   | 16    | 25    | 19  | 14   | 10   | 17     | 13    | 23   | 26   | 20   | 216          |
| 1894 | 20   | 11   | 15    | 24    | 19  | 23   | 19   | 6      | 15    | 23   | 28   | 7    | 210          |
| 1895 | 12   | 16   | 21    | 21    | 20  | 14   | 6    | 12     | 17    | 19   | 18   | 24   | 200          |
| 1896 | 15   | 11   | 13    | 15    | 17  | 16   | 5    | 10     | 11    | 12   | 20   | 22   | 167          |
| 1897 | 9    | 17   | 18    | 22    | 16  | 14   | 6    | 10     | 10    | 15   | 25   | 20   | 182          |
| 1898 | 16   | 18   | 14    | 15    | 19  | 16   | 4    | 9      | 18    | 24   | 20   | 18   | 191          |
| 1899 | 20   | 19   | 20    | 13    | 16  | 16   | 12   | 17     | 26    | 24   | 21   | 17   | 221          |
| 1900 | 20   | 19   | 19    | 16    | 21  | 18   | 16   | 17     | 15    | 23   | 22   | 23   | 229          |
| 1901 | 20   | 16   | 20    | 16    | 23  | 20   | 11   | 16     | 20    | 18   | 19   | 22   | 221          |
| 1902 | 26   | 21   | 22    | 24    | 17  | 28   | 15   | 19     | 18    | 27   | 19   | 21   | 251          |
| 1903 | 17   | 14   | 19    | 23    | 24  | 21   | 24   | 12     | 21    | 31   | 28   | 23   | 257          |
| 1904 | 29   | 25   | 26    | 27    | 27  | 27   | 25   | 21     | 16    | 20   | 27   | 23   | 293          |
| 1905 | 24   | 9    | 16    | 24    | 27  | 23   | 25   | 24     | 22    | 22   | 15   | 21   | 252          |
| Mean | 19   | 17   | 19    | 20    | 20  | 20   | 14   | 14     | 18    | 22   | 22   | 20   | 235          |

Table 27—Wind Movement, Total Miles

| Year | Jan. | Feb. | March | April | May  | June  | July  | August | Sept. | Oct.  | Nov.  | Dec.  | Mean Annual |
|------|------|------|-------|-------|------|-------|-------|--------|-------|-------|-------|-------|-------------|
| 1892 | 3280 | 4010 | 6865  | 5700  | 4500 | 2900  | 2200  | 2500   | 2500  | ..... | ..... | 3200  | 3715        |
| 1893 | 3900 | 4500 | 6500  | 5200  | 5500 | 4500  | 3300  | 3200   | 3400  | 3000  | 3100  | 3800  | 4160        |
| 1894 | 3800 | 4300 | 6000  | 5500  | 5000 | ..... | 4600  | 4000   | 3000  | 2800  | 2700  | 2100  | 3965        |
| 1895 | 3000 | 3800 | 3600  | 4400  | 4070 | 3500  | 4050  | 4080   | 4110  | 3700  | 4950  | 4470  | 3960        |
| 1896 | 4150 | 4400 | 7000  | 6900  | 5450 | 5000  | 4100  | 4200   | 4200  | 3650  | 4000  | 3900  | 4720        |
| 1897 | 4900 | 5250 | 6700  | 6150  | 5800 | 5150  | 4500  | 4200   | 3700  | 4000  | 3650  | 4800  | 4900        |
| 1898 | 4600 | 3850 | 5700  | 7150  | 5600 | 5050  | 4700  | 4300   | 3550  | 3800  | 4500  | ..... | 4800        |
| 1899 | 4750 | 6150 | 7700  | 5750  | 5550 | 5050  | 4100  | 3550   | 3925  | 5700  | 4550  | 4250  | 5060        |
| 1900 | 3965 | 6065 | 5820  | 7240  | 7650 | 5530  | ..... | 5320   | 5485  | 5275  | 4120  | 4830  | 5530        |
| 1901 | 4865 | 4900 | 8020  | 6420  | 7170 | 5800  | 6160  | 4785   | 5525  | 4460  | 3700  | 4615  | 5560        |
| 1902 | 4400 | 6120 | 8355  | 6390  | 5520 | 5300  | 6070  | 4650   | 4660  | 4500  | 4375  | 5535  | 5520        |
| 1903 | 5000 | 5800 | 6475  | 7915  | 7000 | 5100  | 5520  | 5100   | 5200  | 4270  | 3870  | 4450  | 5475        |
| 1904 | 5125 | 5110 | 7475  | 7120  | 7100 | 7110  | 5760  | 5420   | 5120  | 5100  | 3515  | 4210  | 5755        |
| 1905 | 4400 | 4540 | 5950  | 6375  | 6750 | 5110  | 5620  | 4396   | 4780  | 4980  | 4896  | 5115  | 5230        |
| Mean | 4310 | 4900 | 6550  | 6280  | 5925 | 5010  | 4715  | 4260   | 4295  | 4240  | 3995  | 4215  | 4885        |

Table 28—Wind Movement Average Miles per Hour

| Year | Jan. | Feb. | March | Apr. | May  | June  | July  | August | Sept. | Oct.  | Nov.  | Dec.  | Mean Annual |
|------|------|------|-------|------|------|-------|-------|--------|-------|-------|-------|-------|-------------|
| 1892 | 4.4  | 5.8  | 8.6   | 7.9  | 6.0  | 4.0   | 3.0   | 3.4    | 3.5   | ..... | ..... | 4.3   | 5.1         |
| 1893 | 5.2  | 6.7  | 8.7   | 7.2  | 7.4  | 6.3   | 4.5   | 4.3    | 4.7   | 4.0   | 4.3   | 5.1   | 5.7         |
| 1894 | 4.8  | 6.4  | 8.1   | 7.6  | 6.7  | ..... | 6.2   | 5.4    | 4.2   | 3.8   | 3.8   | 2.8   | 5.4         |
| 1895 | 4.0  | 5.4  | 4.8   | 6.1  | 5.5  | 4.3   | 5.4   | 5.5    | 5.7   | 5.0   | 6.9   | 6.0   | 5.4         |
| 1896 | 5.6  | 6.3  | 9.4   | 9.2  | 7.3  | 6.9   | 5.5   | 5.6    | 5.8   | 4.9   | 5.6   | 5.2   | 6.4         |
| 1897 | 6.6  | 7.8  | 9.0   | 8.5  | 7.8  | 7.1   | 6.1   | 5.6    | 5.2   | 5.4   | 5.1   | 6.4   | 6.7         |
| 1898 | 6.2  | 5.7  | 7.7   | 9.9  | 7.5  | 7.0   | 6.3   | 5.8    | 4.9   | 5.1   | 6.2   | ..... | 6.6         |
| 1899 | 6.3  | 9.2  | 10.4  | 8.0  | 7.5  | 7.0   | 5.5   | 4.8    | 5.0   | 7.7   | 6.3   | 5.7   | 6.9         |
| 1900 | 5.3  | 9.0  | 7.8   | 10.0 | 10.2 | 7.7   | ..... | 7.2    | 7.6   | 7.1   | 5.7   | 5.8   | 7.6         |
| 1901 | 6.5  | 7.3  | 10.8  | 8.9  | 10.0 | 8.1   | 8.3   | 6.4    | 7.1   | 6.0   | 5.1   | 6.2   | 7.6         |
| 1902 | 6.4  | 9.1  | 11.2  | 8.9  | 7.4  | 7.4   | 8.1   | 6.2    | 6.5   | 6.0   | 6.1   | 7.1   | 7.6         |
| 1903 | 6.7  | 8.6  | 8.7   | 11.0 | 9.4  | 7.1   | 7.4   | 6.1    | 7.2   | 5.7   | 5.4   | 6.0   | 7.5         |
| 1904 | 6.9  | 7.3  | 10.0  | 9.9  | 9.5  | 9.9   | 9.1   | 7.1    | 7.1   | 6.8   | 4.9   | 5.6   | 7.9         |
| 1905 | 5.8  | 6.8  | 8.0   | 8.8  | 9.1  | 7.1   | 7.6   | 6.0    | 6.6   | 6.5   | 6.8   | 6.9   | 7.2         |
| Mean | 5.8  | 7.2  | 8.8   | 8.7  | 8.0  | 7.0   | 6.4   | 5.7    | 5.8   | 5.7   | 5.5   | 5.6   | 6.7         |

Table 29—Evaporation Record

| Year        | 1899   | 1900   | 1901   | 1902   | 1906           |        |
|-------------|--------|--------|--------|--------|----------------|--------|
| Month       | Inches | Inches | Inches | Inches | Period         | Inches |
| Jan.....    |        | 3.42   | 3.06   | 6.06   | Jan 6—18       | .93    |
| Feb.....    | 4.23   | 4.86   | 2.86   | 7.62   | Jan 18—Mar 15  | 3.87   |
| March.....  | 5.82   | 6.58   | 4.45   | 6.36   | Mar. 15—Apr 11 | 3.87   |
| April.....  | 6.61   | 5.87   | 5.58   | 6.72   | April 11—28    | 2.44   |
| May.....    | 8.06   | 6.46   | 7.94   | 7.56   | Apr 28—May 5   | 1.50   |
| June.....   | 9.06   | 5.98   | 7.80   |        | May 5—19       | 2.95   |
| July.....   | 4.94   | 6.72   | 5.58   |        | May 19—26      | 1.46   |
| August..... | 5.80   | 8.64   | 6.25   |        | May 26—June 2  | 1.45   |
| Sept.....   | 5.98   | 7.02   | 5.94   |        | June 3—10      | .80    |
| Oct.....    | 4.65   | 5.52   | 5.00   |        | June 10—July 3 | 3.78   |
| Nov.....    | 3.48   | 3.73   | 3.24   |        |                |        |
| Dec.....    | 2.94   | 5.43   | 4.43   |        |                |        |
| Total....   | 61.43  | 70.23  | 62.32  | 34.32  |                | 23.05  |





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**BULLETIN NO. 60**

**NOV., 1906**

**New Mexico College of Agriculture and Mechanic Arts**

**AGRICULTURAL EXPERIMENT STATION**

**AGRICULTURAL COLLEGE, N. M.**



**PRICKLY PEAR AND OTHER CACTI  
AS FOOD FOR STOCK II.**

BY

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**Assistant Agrostologist, U. S. Department of Agriculture,**

AND

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**SANTA FE, N. M.:  
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1906.**

# NEW MEXICO AGRICULTURAL EXPERIMENT STATION

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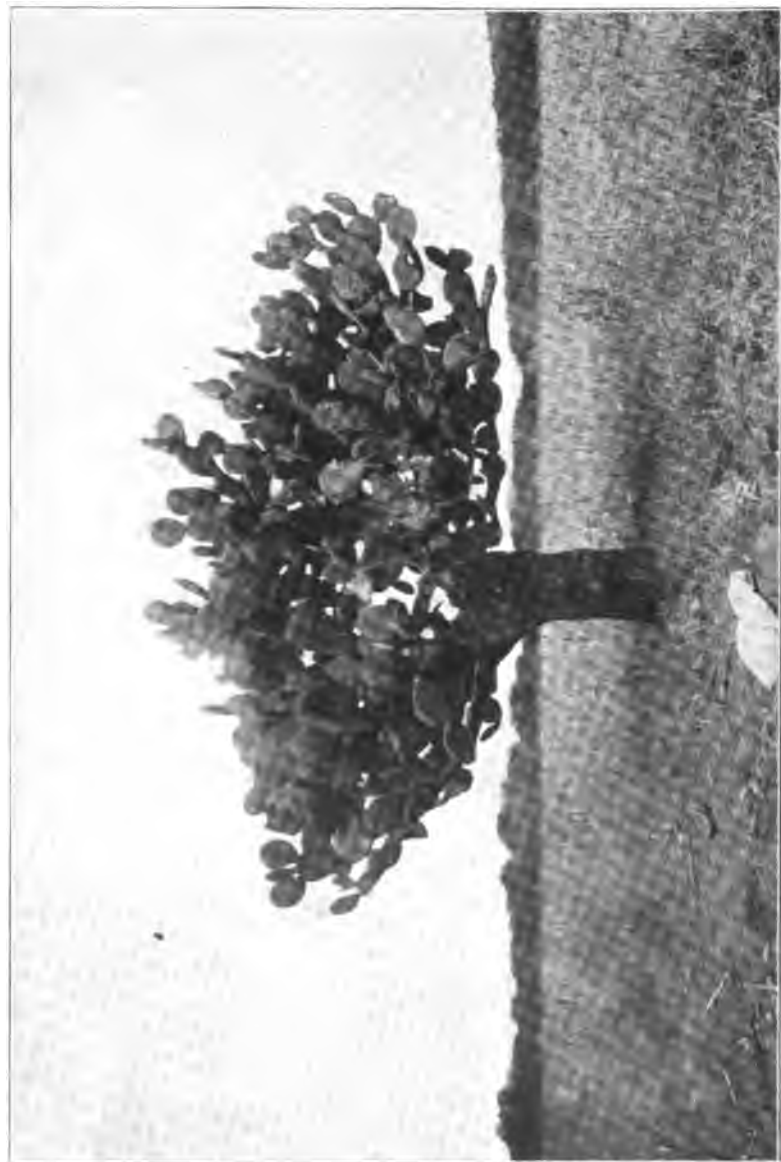
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**PLATE I. Nopal Cardon. (*Opuntia Streplacantha* Lem.)**

## PREFACE

In two publications of the United States Department of Agriculture (B. P. I. Bulletin No. 74 and B. A. I. Bulletin No. 91) the value of the cacti as forage plants has been demonstrated. Since these plants are known to possess important economic value, more knowledge concerning them is desirable. As a basis for future investigations, the Bureau of Plant Industry and the New Mexico Experiment Station have collected material from a wide area, from which a large number of chemical analyses have been made. The results are detailed in the following pages. 187 food analyses and 26 complete ash analyses are here reported. The territory from which the material was collected extends from central Texas to California, and southward to the central plateau of Mexico.

Attention is called to the fact that the apparent high content of fats and protein in the fruit [of certain species is due to the large amount of these classes of nutrients found in the seed. As these seeds are surrounded by a dense layer of wholly indigestible tissue, the high content of ether extract and protein is misleading. The analyses show that the fodder value of the fruit of cholla (*O. fulgida*) and related species investigated is little more than that of the stems. It will be seen that in chemical composition the different forms of cactus compare favorably with ordinary green fodders and root crops.

There are many points of special interest in connection with the ash analyses, especially the high content of potash, magnesium and calcium. Altho the cane cacti show a relatively higher food value, practical considerations relating to growth and ease of propagation render them of less value than the prickly pear, except in certain limited localities where they are especially abundant.

W. J. SPILLMAN,  
Agriculturist.

Farm Management Investigations,  
Washington, D. C., October 19, 1906.

# **PRICKLY PEAR AND OTHER CACTI AS FOOD FOR STOCK II<sup>1</sup>**

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## INTRODUCTION

When a study of the economic value of the *Cactaceae* was taken up in earnest, three or four years ago, it was recognized that a better knowledge of the chemical composition of the prickly pears was necessary. When this work was undertaken it was decided that the investigation should include promising foreign species as well as native ones and that it could be most profitably taken up in connection with introductions and other investigations then in progress. Considerable chemical work had already been done upon the various forms but an examination of the appended list of literature will show the number of analyses made from the forage standpoint to have been comparatively few and that they were still fewer in number when this work was begun than they are at the time of its publication.

Analyses of some forms are appended here which can never be of any great importance as feed for stock on account of their slowness of growth. This is especially true of those forms outside of the genus *Opuntia*, but the inclusion of analyses of these forms is instructive as a matter of comparison. Some use is made of all of the species. Accounts of the profitable utilization as feed for stock of such unpromising forms as the *Viznaga* are given in the text and such small forms as the *Echinocacti* described can be made use of in connection with such other forms as they happen to grow with.

The methods of feeding cacti were described in detail in Bulletin No. 74 Bureau of Plant Industry, U. S. D. A. and the use of the prickly pear in the present beef and butter production of Texas has been reported upon in bulletin No. 91 Bureau of Animal Industry of the same Department. The reader is referred to these publications for additional discussions which might be looked for here.

When the work was planned it was thought that 40 chemical analyses would cover the ground fairly well but as the investigations progressed so many forms having more or less value were discovered that the scope of the investigations was very much enlarged. The uncertainty arising from chemical analyses of single samples also had an influence in the extending of the investigations beyond the limits first contemplated.



## ACKNOWLEDGMENTS

Due credit should be given Mr. S. R. Mitchell, Assistant Chemist at the New Mexico Experiment Station for valuable assistance rendered in the chemical analyses, as well as in the compilation and tabulation of the results of analyses given in this bulletin. Professor E. O. Wooton has also given valuable assistance in collecting material as well as in its identification, and Professor William Trelease has aided very materially by according us the free use of the Engelmann Herbarium at the Missouri Botanical Garden. All collections, unless otherwise indicated, were made by the authors. The authors are under special obligation to Mr. A. S. White for privileges accorded them in studying as well as in securing specimens from his extensive collections.

### The Samples

It has been considered important throughout the investigations to record as minutely as possible the character of the samples which were analyzed. No one appreciates better than the writers the absolute impossibility of securing exact uniformity in any set of samples of plant tissues, more especially ones which vary as do the cacti. Although uniformity cannot be secured, a record has been attempted which will give a clear idea of the nature of the sample. A plan was adopted when the work began which will enable the reader to know very definitely the portion of the plant used. The importance of this is clearly shown in some of the analyses.

In order to condense the descriptions of the samples, a formula is adopted to designate the relative position of the parts of the plants analyzed. This can best be explained from an actual diagram:

2-1-4-3-5.

In this formula the left hand figure represents in all cases the terminal mature joint or, in one or two instances, the last proliferous fruit produced on the plant; the second figure from the left, the second joint, &c. In general, the left hand

figure in the formula indicates the number of one-year old joints in the sample, the second the number of two-year old joints, the third the number of three-year old joints, the fourth the number of four-year old joints, &c. By remembering that the left hand figure in the formula represents the terminal joint, there will be no difficulty in interpreting the sample formulae. When this formula is given within a parenthesis the figure on the outside denotes the number of plants from which the samples were taken.

It is not strictly accurate to say that position in the formula represents the age in years of the joints, because the time it takes for a joint to grow is extremely varied. This depends upon the soil and climatic conditions as well as upon the age and species of the plant. Some years some terminal joints put forth no new growth, while the next may witness the development of two joints. Again, fruiting joints seldom produce new vegetative growth the same year that they do fruit. It has been the common belief that in plants which have reached the fruiting stage one joint per year is produced by the terminal joint of the previous year. While this possibly might be accepted, it is a very rough approximation and overestimates rather than underestimates the actual growth of the plant.

It should be clearly understood that in no case where not expressly stated is any new growth included in the samples. Only mature joints or those which had passed through a winter season have been included. The left hand figure in the formulae of samples collected in 1904, therefore, represents joints which grew in 1903.

Through a misunderstanding a slight error occurs in some of the formulae of the samples collected in 1904. When these were sent to the laboratory joints were set aside for botanical purposes. In every case such joints have been deducted from the total but it was impossible to tell the difference in the dried samples between joints two, three or four years old. The best that could be done was to determine whether or not the joint was a terminal one and make the deduction accordingly,

either from the terminal joint or from some of the others. It will readily be seen that this introduces but a slight error. All of the samples collected in 1905 are exactly as represented in the formulae.

The uncertainty of the chemical analysis of a single sample influenced us to make a special effort to secure two samples of each species or form and this has been very largely accomplished. In the majority of cases the two samples have been collected one year apart from the same plants, the localities having been visited two or, in several cases, three times during the period that these investigations have been in progress.

The transportation of specimens from the field to the laboratory, while satisfactorily arranged finally, was not by any means an easy matter. Inasmuch as it appeared wise to secure as accurate data as possible upon the water content in the green state, the evaporation in transit was difficult to overcome. Fortunately, these plants do not give up their moisture as readily as many do, and the extent of cut surface may be very much minimized in the prickly pears especially, by securing whole joints. But in hot weather the evaporation in transit would be considerable even then. It was finally decided to ship all material to the laboratory in tin cans and to secure those from which there would be the least possible evaporation. It was impracticable to have such vessels made and carried into the field, so it was necessary to buy such as were needed from time to time upon the different convenient markets.

Many kinds of vessels were used. Coffee and baking-powder cans were on the whole the most satisfactory. But tin pails with tight fitting covers and, with small samples, ordinary fruit cans were often employed. The latter, however, were difficult to obtain except upon a few markets. These packages were wrapped and securely tied in several thicknesses of heavy paper and usually inclosed in a cloth sack to be forwarded by either mail or express.

On the whole the method was very satisfactory but it was

impossible to get some of the fruits to the laboratory in good condition. The fruits of both *Echinocereus enneacanthus* and *Cereus geometrizans* spoiled in transit. By wrapping carefully picked fruits in paper, and packing the joint samples free from bruises all other samples came to the laboratory in good condition. Many of the samples were in transit but 24 to 48 hours.

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### METHODS OF CHEMICAL ANALYSIS

The methods of the Association of Official Agricultural Chemists were used in the fodder analyses included in this bulletin.

In the determination of a number of the elements included in the ash analysis, the A. O. A. C. methods were modified. The analyses were made from the ash, which was prepared by burning the plant in platinum dishes in a muffle furnace at a low temperature, no attempt being made to determine the total inorganic plant constituents.

#### Preparation for Analysis

Upon receipt of the samples in the laboratory they were at once weighed, and sliced in such a manner as to expose as much as possible of the inner portion for drying. After a number of unsuccessful attempts it was found impracticable to air dry many of the samples, even in the summer sun of New Mexico, because of their tendency to ferment when sliced, or to continue growing if left as whole joints. It became necessary, therefore, to dry many of the samples by means of artificial heat; and for this purpose an old incubator was used, the temperature of which was kept at or below 70° C. until the samples were dried. It has been found that drying such succulent plants as the cacti at this temperature can be effected without causing a change in their chemical composition. By this treatment the samples were dried in good condition.

After drying, the samples were allowed to remain exposed to the air for several days so that they might assume an *air*

dry condition, when they were again weighed and the loss in weight from the weight of the fresh sample gave the amount of water lost in air drying.

#### Removal of the Spines

After drying and weighing, the spines were next removed from the sample. As one of the most common methods of feeding cactus is to first singe off the spines, it was decided to prepare all of these samples in that manner, so that we might more nearly represent the condition of the plant when fed to animals. Instead, however, of removing the spines from the green material as is done in feeding, they were carefully singed from the *air dry* plant with a small flame of complete combustion. Usually we experienced no difficulty in removing the spines in this manner, as they burned off with a flash without scorching the dried plant. It was the intention at first to remove them by "singeing" the green plant, as is done in feeding, and with a few of the samples collected in 1904 the spines were removed in this manner, but it was soon found that this could not be done without driving some moisture from the sample, thus yielding too high results for percentage of spines, and a slightly low result for water. A similar difficulty was encountered with some of the first few samples in trying to remove the spines from the green material by means of a knife. For this reason, as well as for the reason that it was entirely too tedious a process, this method was abandoned, except for a very few species that had spines entirely too large to be "singed" without danger of overheating the sample. Where samples of the same species, collected in 1905, showed that an apparent error had been introduced by removing the spines from the green material by either of the above processes, the results so obtained have been omitted from the tables of analyses. The percentage of spines was calculated from the difference in weight before and after burning the sample as just described. Where the amount of spines is determined in the air dried plant the results will be slightly low when calculated

to a basis of percentage in green plant, because the spines themselves were found to contain from five to ten per cent. of water.

The amount of spines found on the different species varies widely. Some are spineless, while in a few extreme cases the spines constituted as much as 35 to 40 per cent. of the dry matter of the plant. There is also a great variation in the percentage of spines found on different samples of the same species, depending as a rule upon the size and age of the stems. Very old stems frequently have lost many of their spines and therefore may be almost if not quite spineless. No. 7516 was a sample of this kind, and while the results of the analysis show only a few, there was at one time, no doubt, an appreciable quantity of spines. When a sample is made up of a number of small joints the percentage of spines is much higher than when the joints are all large. No. 3101 was such a sample of the same species as Nos. 3018 and 3100, and while the results indicate over twice as many spines, the probabilities are that they were no more numerous, nor larger than those in the last named samples. In some species the old trunks seem to be normally more spiny than the younger joints. Exceptions to this rule were found in a number of instances, however, and these can only be accounted for by the fact that the spines are naturally more abundant on some stems than they are on others, even when the samples are taken from the same plant, but it is believed that this determination will be of value in giving an approximate idea of the relative percentage of spines in the different species.

Where the percentage of spines amounted to less than 1-10 of one per cent. in the dry material they have been noted in the table as "few." This is the case with nearly all of the fruits, as the spines on these are usually so small that their relative weight is inappreciable.

To determine definitely what, if any, food value was lost in burning the spines from the plant, a sample was collected from No. 3070a and the results reported under No. 3070b

(Table No. 6.) As might be expected they were found to be composed largely of crude fiber, there being 44.17 per cent. in the green spines. It is interesting to note that they contained only 8.73 per cent. water, and 3.73 per cent. ash. While there is considerable nitrogen-free-extract, it is doubtful if any appreciable amount of this would be available to animals. Hence probably very little of value is removed from the plant in "singeing" its spines; on the other hand, much objectionable matter is thus removed and the food is somewhat concentrated by the loss of its spines and some of its water. This fact points more favorably to the method of "singeing" than to that of "chopping" in the preparation of cactus for food, although, of course, this would not be of much consequence except in species that contained a great many spines.

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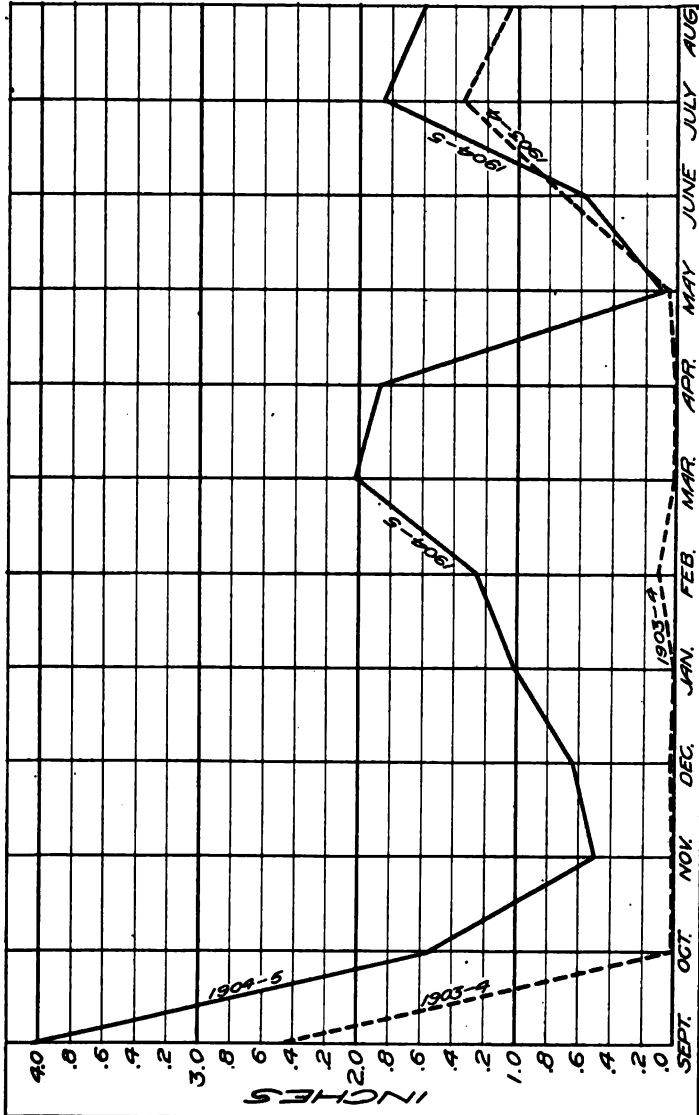
#### WATER CONTENT

The amount of water in the different samples analyzed varied from 60.99 to 95.5 per cent., omitting No. 6531 because of a probable error in the moisture determination. The miscellaneous group contains more water than do either of the other two, the average amount of water in this group being 87.88 per cent., while the prickly pears averaged 84.26 per cent. and the cane cacti 78.47 per cent.

As a rule the fruits contained more water than did the stems, and the younger growth more than the older. There was more water in those samples collected in 1905 than in those collected in 1904. This fact was no doubt due to the prolonged drouth, quite prevalent over the regions where the samples were collected during the winter of 1903 and the spring of 1904, which was followed by heavy rains during the next winter and spring thus causing the growth in 1905 to be more succulent.

The figures showing the precipitation in inches and tenths for the years 1903-4 and 1904-5 from September 1st of each year are plotted in the diagram below, and a glance at this is sufficient to explain the variation in the water content of the

## PRICKLY PEAR AND OTHER CACTI



Map showing precipitation in inches and tenths at the New Mexico Experiment Station from September first to August thirty-first, during the years 1903-04 and 1904-05.



samples for the two years. In one instance the difference in water amounts to 18.86 per cent. These figures were taken at the New Mexico Experiment Station and while such a condition was doubtless prevalent over the area where the samples were collected, they necessarily apply only to southern New Mexico.

Cactus, as a rule, contains more water than other green fodders, in fact, in point of water content, it more nearly approaches roots and tubers.

The above statements apply to the question in general. The effect of rainfall on the water content is more specifically brought out in the following tabular statement correlating the water content of the samples with the rainfall in regions where several of samples were collected.

**Table 1.—Showing Relation of Rainfall to Water Content of the Prickly Pear.**

| No             | Name                         | Locality where collected | Date of collection. | Precipitation during past three months. (Inches) | Percentage of water in plants. |
|----------------|------------------------------|--------------------------|---------------------|--------------------------------------------------|--------------------------------|
| } 6243<br>7787 | Opuntia engelmanni           | Santa Rita Mts. Arizona  | April 30, 1904      | .28                                              | 79.05                          |
|                | " "                          |                          | April 19, 1905      | 9.15                                             | 87.86                          |
| } 6240<br>7774 | Opuntia engelmanni           | "                        | April 29, 1904      | .28                                              | 72.60                          |
|                | " "                          |                          | April 18, 1905      | 9.15                                             | 86.19                          |
| } 6247<br>7790 | Opuntia engelmanni cycloides | "                        | May 2, 1904         | .28                                              | 81.94                          |
|                | " "                          |                          | April 20, 1905      | 9.15                                             | 79.69                          |
| } 6248<br>7791 | " "                          | "                        | May 2, 1904         | .28                                              | 72.65                          |
|                | " "                          |                          | April 21, 1905      | 9.15                                             | 81.00                          |
| } 7009<br>7559 | Opuntia phaeacantha          | "                        | Aug. 30, 1904       | .28                                              | 88.83                          |
|                | " "                          |                          | April 17, 1905      | 9.15                                             | 83.93                          |
| } 6241<br>7782 | Opuntia chlorotica           | "                        | April 30, 1904      | .28                                              | 77.87                          |
|                | " "                          |                          | April 19, 1905      | 9.15                                             | 79.47                          |
| } 6609<br>7805 | Cereus giganteus             | Tucson, Ariz             | July 28, 1904       | .60                                              | 87.31                          |
|                | " "                          |                          | April 26, 1905      | 11.56                                            | 92.36                          |

In general, the samples collected in 1905 contained more water than those collected in 1904. There are two exceptions in the above tabular statement. If the descriptions of samples No. 6247 and 7790 are compared, it will be found that the

1904 sample contained proportionally much more of the younger growth. It is therefore quite likely that the difference in the samples may account for their apparent deviation from the general rule. Our notes show no explanation for the condition shown in Nos. 7009 and 7559.

Cholla (*Opuntia fulgida*) is especially susceptible to changes during favorable seasons. The younger joints of this species are ordinarily very succulent. During the spring of 1905, after the exceptionally favorable winter season, it was not at all uncommon to find branches and fruits of this species actually ruptured by the excessive pressure due to the absorption of large quantities of water. The phenomenon is sometimes to be seen in the prickly pear forms but never to such an extent as in this species. It is especially common at times in the fruits of certain cultivated Mexican forms. Photographs taken of the plant shown in Plate VI, Figure 2, show over one-half of the fruits upon it to be ruptured.

While the prickly pear is, in the vast majority of cases in this country and elsewhere, an emergency feed, being used when other more nutritious substances fail, it has a limit of drouth endurance. There have been seasons in southern Texas with drouth so prolonged that the pear was fed only with difficulty. It had lost its crisp and succulent nature and become fibrous and tough so that those who fed found it much more advantageous to chop than to scorch because cattle could eat it better when it was cut for them. The effect upon these plants of an unfavorable season is fully as marked as upon the common cultivated crops. The advantage lies in the ability of the pear to withstand a longer period of unfavorable weather without serious or permanent injury.

#### ASH CONTENT

Plants grown in the arid or semi-arid southwest, where there is an abundance of soluble salts in the soil are found to contain more ash than those grown in regions of frequent rainfall; and the cacti are a group of plants that are certainly no exception to this rule. The average ash in the air dried

| Number |                  |
|--------|------------------|
| 6244   | Opuntia arbusc   |
| 6251   | " versic         |
| 6255   | " fulgid         |
| 6256   | " mam            |
| 6228   | " lept           |
| 6331   | Echinocereus e   |
| 65172  | Opuntia sp. .... |
| 6525   | " micr           |
| 6527   | " imbr           |
| 6535   | " sp. ....       |
| 8000   | " macr           |
| 8002   | " engel          |
| 6699   | Cereus gigante   |
| 3016   | Opuntia sp. .... |
| 3018   | " polya          |
| 3025   | " phae           |
| 3082   | " laevis         |
| 7476   | " caca           |
| 7515   | " lindh          |
| 7591   | " strep          |
| 7733   | " sp. (N         |
| 7734   | " rufid          |
| 7774   | " engel          |
| 7782   | " chl            |
| 7784   | " phae           |
| 7790   | " engel          |
| 7791   | "                |

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stems and fruits of the prickly pear group amounted to 18.25 per cent., for the cane cacti 15.50 per cent., and for the miscellaneous group 13.54 per cent. In one sample (No. 6578) ash was 33.08 per cent. of the dry plant. The averages would all be higher if they did not include the fruits, which always contain less ash than do the stems. The average ash in the air dry fruits of the prickly pears, for instance, is 13.21 per cent., which is 5.04 per cent. less than is contained in the average of both stems and fruits of this group.

The greater part of the ash in the fruits is found in the fleshy portion rather than in the seed, in fact the fleshy portion contains about the same amount as is found in the stems. Sample No. 8022a is of the fruit with seed removed, and contained 25.60 per cent. ash, while the seed alone, the analysis of which is given under No. 8022b, contained only 1.77 per cent. ash in the dry material. The low ash content of the seed is undoubtedly what causes the whole fruit to be low in this substance.

The elements of the ash are present perhaps in about the same proportion as in the ash of other plants, except potassium, magnesium, and calcium, which are present in unusually large amounts, due, no doubt, to the fact that salts of these three elements are usually found abundant in most southwestern soils. It is the presence of these salts, in all probability, that causes animals that eat cactus alone to scour so badly. If, for example, a steer should eat 100 pounds of the green plant from sample No. 6578, he would get only 7.96 pounds of organic matter, and in addition to 88.11 pounds of water, he would eat 3.93 pounds of ash, or residue from the ignition of these salts. This would be considered a rather large dose if they were in any way purgative, as some of the magnesium, sodium and potassium salts present undoubtedly are. Manganese is present in unusual amount in a number of the ashes, enough being present in some of the plants to impart a characteristic green color to the ash. It amounted in one instance (No. 7782) to more than one per cent. of the total ash.

The results reported in the table of ash analyses are calculated to the pure ash, and the elements are reported as kathions and anions. It will be noticed that when the results are so reported the sum total of all the constituents amounts to less than 100 per cent. in all but two samples. This is probably accounted for, in part at least, by the presence of small amounts of oxides or hydroxides of calcium or potassium in most of the samples. The presence of these was shown by the alkalinity of the filtrate from the water solution which had been previously precipitated with neutral barium chloride. When the results were calculated to oxides they approximated 100 per cent., but oxygen was lost in converting these results to radicles, because of an excess of basic radicles.

#### Food Value of Different Parts of the Plant

In the pear region of southern Texas there is a universal belief that the old woody stems are of more value as feed than the younger joints. Indeed it is the practice in some localities to cut off one or two terminal joints, using only the remainder of the stem. Some feeders go so far as to insist that they would feed only the old trunks if they could get enough of them without too much labor. Of course, these opinions and remarks refer only to the southern Texas species, *Opuntia lindheimeri*, which grows only four or five feet high and has a comparatively small trunk. There are many species in Mexico whose trunks are so woody that they would be absolutely worthless as feed for stock. The stems of the Texas species are much more succulent than the larger, ranker forms of Mexico. Our analyses show that the old stems of *Opuntia lindheimeri* contain less water and more crude fiber than the younger growth and are of less food value. On the other hand, a smaller water content is of course a decided advantage in such exceedingly succulent feed.

Guthrie<sup>1</sup>, after comparing his own analysis of the stems of

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1. Agric. Gaz. N. S. W. 11: 671. 1900.

four Australian species with the analysis of fruits made by Wolf, concludes that the latter are of less forage value than the stems because they contain a smaller proportion of nutritious substance and more fiber. Forbes <sup>2</sup>, on the other hand, suggests from analysis of cylindrical jointed cacti that the fruits of certain Arizona species are rich in fat and consequently greatly relished by cattle.

Comparative composition of the different parts of the fruit.

Analysis of fruits of the cacti usually shows them to contain more fat and protein than is found in the stems, but when the seeds are separated from the fruits and analyzed they are found to contain most of the food material of the whole fruit, See 8022a and 8022b in the table beyond. However, since the seeds are not masticated by cattle and pass through undigested, probably none of this part of the fruit is available as food hence it would seem that the fruits of many species at least are not so valuable for stock food as the edible portions of the stems. This is especially true of such species as *O. fulgida* and *O. spinosior*. Stock doubtless eat the fruits of these species in preference to the stems because they have fewer spines, not because they are any more nutritious. There are, however, a few fruits especially from those species collected in Mexico, which are very nutritious because of their higher sugar content.

The fruit of *Echinocactus* (Nos. 8173a and b) and the "miscellaneous" group in general are very different inasmuch as the seeds of these species can be easily masticated. But from the forage standpoint these fruits can all but be ignored. The fiber in the seed of these samples (Nos. 8173a and b) was not more than half of the amount found in No. 8022a, for example, and the seed of the other species of prickly pear resemble No. 8022a in their general properties, and probably in the fiber content also.

It is interesting to note that *O. fulgida* No. 8170a contains very little more food in the whole fruit than is found in the pulp and rind alone. This is probably due to the fact that the

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2. Ariz. Agric. Expt. Sta. Ann. Rep. No. 15, 496. 1904.

seeds in this sample are sterile. No. 7801, which was a normal specimen with fertile seed, is apparently higher in food value but we suspect that this is only apparent and that here again the nutritive material is locked up in the seeds, of which there were a normal number, while No. 8170a was largely sterile.

**Table No. III—Showing Composition of the Different Parts of Fruits**

| Name.                              | No.   | Part of fruit. | Water. | Ash. | Protein. | Fat.  | Nitrogen free extract. | Fiber. | Organic matter. |
|------------------------------------|-------|----------------|--------|------|----------|-------|------------------------|--------|-----------------|
| <i>O. phaeacantha.</i>             | 8022a | Seed           | 7.26   | 1.75 | 6.07     | 11.41 | 23.18                  | 50.33  | 90.99           |
| "                                  | 8022b | Pulp           | 92.50  | 2.09 | .20      | .07   | 4.63                   | .51    | 5.41            |
| <i>O. spinosior.....</i>           | 8162a | Whole fruit.   | 77.74  | 2.97 | 1.74     | 1.11  | 11.50                  | 4.94   | 19.29           |
| "                                  | 8162b | Pulp           | 83.04  | 3.10 | .55      | .24   | 11.74                  | 1.33   | 13.86           |
| <i>Echinocactus Wislizeni.....</i> | 8173a | Seed           | 8.59   | 3.09 | 10.92    | 15.45 | 36.59                  | 25.37  | 88.31           |
| "                                  | 8173b | Pulp           | 94.14  | .96  | .63      | .06   | 3.06                   | 1.16   | 4.90            |
| <i>O. falgida.....</i>             | 8170a | Whole fruit.   | 82.84  | 2.70 | .63      | .51   | 11.63                  | 1.69   | 14.46           |
| "                                  | 8170b | Pulp           | 87.17  | 1.58 | .47      | .27   | 9.66                   | .91    | 11.25           |

**Relative Food Value of the Three Groups.**

Chemical analysis indicates that the cane cacti are the most valuable of the three groups as a food. They contain more protein, fat, and nitrogen-free-extract than do either of the other two groups.

The miscellaneous species which include all the specimens not belonging to the platopuntias and the cylindropuntias, contain more spines and water, and less ash than does either of the other two. They also have more protein, fat, and nitrogen-free-extract in the dry material, but because of the large amount of water, the green plants contain less protein and fat than do the cane cacti and less nitrogen-free-extract than either cane cacti or prickly pears.

But this is only a portion of the story, for while chemical analysis is of great importance in determining the value of any food stuff, there are other problems which must be considered. The cane cacti, are as a rule, drier and contain more



fiber and are consequently less suited to the practical stockman's use. *O. fulgida* is without doubt the most valuable cylindrical jointed species growing within the borders of the United States, but for various reasons it cannot compare in value with many of the flat jointed forms, because they grow more rapidly, are easier to propagate from cuttings, and are more abundant naturally over a greater extent of territory, are all of which are of vital importance in the economic handling of the crop.

The ash is highest in the prickly pear, but the fruits of the cane cacti contain more ash than the fruits of the other groups.

In table No. IV is given the average analysis of the three groups, and for the purpose of comparing their relative value with other green fodders we have included the analysis of ten very commonly fed green fodders, roots and tubers. Since *Opuntia Lindheimeri* is a very important species, it being the one at present most commonly fed in Texas, we have also included an average of the analysis of seven samples of stems and one of the fruits of this species collected during 1904 and 1905.

It will be seen that this average of analyses of *O. Lindheimeri* shows practically the same amount of constituents as does the average of all the prickly pears. It will also be seen that the cacti resemble other green fodders very much in their composition. Perhaps they average somewhat more water and ash, and less protein and fat.

Table No. IV. Comparative Composition of the Three Groups with Other Green Fodders, Roots and Tubers.<sup>1</sup>

|                                         | Spines | Water. | Ash  | Protein | Fat  | Nitrogen Free Extract | Fiber | Organic Matter |
|-----------------------------------------|--------|--------|------|---------|------|-----------------------|-------|----------------|
| Cane Cacti <i>Cylindropuntias</i> ..... | .79    | 78.47  | 3.61 | 1.41    | .63  | 12.30                 | 3.59  | 17.63          |
| Miscellaneous Cacti .....               | 1.08   | 87.88  | 1.67 | 1.06    | .41  | 7.22                  | 1.76  | 10.45          |
| Prickly Pears <i>Platopuntias</i> ..... | .44    | 84.26  | 3.06 | .73     | .34  | 9.04                  | 2.41  | 12.53          |
| <i>Opuntia Lindheimeri</i> .....        | .....  | 84.51  | 3.18 | .73     | .33  | 8.59                  | 3.65  | 12.30          |
| Corn—dent, cut before glazing.....      | .....  | 79.7   | 1.20 | 1.70    | .50  | 11.50                 | 5.40  | 19.10          |
| Pasture grass.....                      | .....  | 80.00  | 2.00 | 3.50    | .80  | 9.70                  | 4.00  | 18.00          |
| Sorghum.....                            | .....  | 79.40  | 1.10 | 1.30    | .50  | 11.60                 | 6.10  | 19.50          |
| Rye.....                                | .....  | 82.00  | 1.60 | 2.40    | .70  | 8.50                  | 4.80  | 18.40          |
| Alfalfa.....                            | .....  | 71.80  | 2.70 | 4.80    | 1.00 | 12.30                 | 7.40  | 25.50          |
| Red clover.....                         | .....  | 70.80  | 2.10 | 4.40    | 1.10 | 13.50                 | 8.10  | 27.10          |
| Carrots.....                            | .....  | 88.60  | 1.00 | 1.10    | .40  | 7.60                  | 1.30  | 10.40          |
| Potatoes.....                           | .....  | 78.90  | 1.00 | 2.10    | .10  | 17.30                 | .60   | 20.10          |
| Sugar Beets.....                        | .....  | 86.50  | .90  | 1.80    | .10  | 9.80                  | .90   | 12.60          |
| Turnips.....                            | .....  | 90.50  | .80  | 1.10    | .20  | 6.20                  | 1.20  | 8.70           |

1. The analysis of green fodders, roots and tubers given in this table were taken from Bull. No. 11, Office of Experiment Stations, U. S. D. A.

In the average analyses of the cane cacti and prickly pears given in the table above it will be seen as before stated that the cane cacti contain the nutrients in larger quantity. An examination of all the samples in each group as shown in table No. VI reveals the fact that a larger proportion of fruits is included in the average of the cane cacti, and at first sight one might conclude that this would at least account for the larger amount of protein and fat in the cane cacti as shown by the averages. If this were the case a fair comparison of the value of the two groups could not be made in this manner since the seed of the fruits hold these nutrients securely

locked from the reach of cattle at least, and a true comparison would have to be made between an average of the stems alone.

Below is given a table showing the average composition of the stems alone of these two groups as well as an average of the stems of *O. fulgida* and *O. lindheimeri*, and for the purpose of comparison the average of the stems and fruit of each group has also been included.

A study of this table will reveal the fact that the high protein and fat content of the cane cacti is not due to the presence of a larger number of fruits analyzed as compared to the number of fruits of the prickly pears. Neither can it be accounted for very often by the fact that the prickly pear contains the more water, since the nutrients are usually present in larger quantity in the air dry cane cactus.

Table No. V.—Showing the comparative average composition of the stems, and stems and fruits, of cane cactus and prickly pear, and the average composition, of the stems of the two typical species of each group

| GREEN MATERIAL. |                |        |      |                |            |                        | AIR DRY. |                 |        |       |                |            |                        |        |                 |
|-----------------|----------------|--------|------|----------------|------------|------------------------|----------|-----------------|--------|-------|----------------|------------|------------------------|--------|-----------------|
| Name.           | Part of plant. | Water. | Ash. | Crude protein. | Crude Fat. | Nitrogen-free-extract. | Fiber.   | Organic Matter. | Water. | Ash.  | Crude protein. | Crude Fat. | Nitrogen-free-extract. | Fiber. | Organic Matter. |
| Prickly Pear..  | Stems.....     | 83.31  | 3.45 | .77            | .3         | 9.85                   | 2.38     | 13.31           | 5.93   | 19.56 | 4.47           | 1.74       | 54.83                  | 13.43  | 74.46           |
| O. linhelmeri.. | Stems.....     | 83.41  | 3.48 | .75            | .31        | 9.41                   | 2.64     | 13.11           | 5.89   | 19.03 | 4.28           | 1.80       | 54.48                  | 14.51  | 75.07           |
| Cane cactus..   | Stems.....     | 75.91  | 4.32 | 1.62           | .45        | 13.45                  | 3.90     | 19.73           | 6.34   | 16.50 | 6.36           | 1.74       | 54.19                  | 14.59  | 77.13           |
| O. fulgida..... | Stems.....     | 75.63  | 3.05 | 1.04           | .37        | 16.99                  | 2.63     | 21.33           | 6.46   | 11.85 | 4.15           | 1.43       | 65.92                  | 10.19  | 81.70           |
| Cane cactus..   | Stems & fruit. | 78.47  | 3.61 | 1.41           | .63        | 12.30                  | 3.59     | 17.93           | 6.15   | 15.50 | 6.09           | 2.77       | 51.32                  | 15.17  | 78.85           |
| Prickly Pear..  | Stems & fruit. | 81.24  | 3.03 | .73            | .34        | 8.95                   | 2.36     | 12.54           | 5.91   | 18.05 | 4.65           | 2.22       | 54.23                  | 14.61  | 76.82           |

### A BALANCED RATION OF PEARS

To determine in just what proportion cactus should be fed with other foods to produce a balanced ration it is necessary to know the amount of digestible nutrients contained in the cactus, as well as those of the food or foods with which it is to be fed. This has been determined for most foods, but unfortunately as yet we have no such data for the cacti. We hope to be able soon to obtain the co-efficient of digestion for *O. lindheimeri*. For the present, all that can be done is to assume this digestibility co-efficient to be the same as that of some food as similar in chemical composition and properties to the cacti as possible. It is somewhat difficult to secure a green fodder very similar in character to cactus, but perhaps we will not miss its digestion co-efficient very far by assuming it to be the same as that of immature green corn fodder. By using the co-efficient for this fodder we find the nutrients in *O. lindheimeri* to be protein .47 per cent., fat .26 per cent., and carbohydrates 7.85 per cent. This being the case, cactus would have a nutritive ratio of 1:18, a ratio which, according to the best authorities, would prohibit its use alone for any feeding-standard. The nutritive ratio for a standard ration varies from 1:4 to 1:12, depending upon the age, character, and kind of animal to be fed, as well as the object of the feeding; that is, whether it is desired to produce work, flesh or milk,

If the object of feeding is to produce milk, a cow giving a heavy yield of milk should, according to the best authorities, be fed about 25 to 30 lbs. of organic matter per day, containing from 1.8 to 2 lbs. of digestible protein, from .4 to .7 lbs. of digestible fat, and 11 to 13 lbs. of digestible carbohydrates, making a nutritive ratio of from about 1:5.5 to 1:7. If a cow requiring a ration of this kind should eat cactus alone, it would take 160 lbs. to furnish the fats and carbohydrates, and an additional 240 lbs. to furnish sufficient protein, and since to avoid "scouring" a cow should probably not be fed to exceed 50 or 60 lbs. of cactus a day, it may be readily seen

how impossible it would be for a milk cow to get even a one-sided ration from cactus alone.

A ration of 40 lbs. of cactus with 10 lbs. of wheat bran and 12 lbs. of corn stover would furnish the nutrients in somewhat near the proper proportion. In a ration of this kind the cow would get 21.16 lbs. of organic matter, containing 1.68 lbs. of protein and 11.82 lbs. of carbohydrates and .49 lbs. of fat, which is in a ratio of 1:7.7.

If a ration is desired in which the cactus is fed with dried brewers' grain and cottonseed meal, it could be made by feeding 60 lbs. of cactus with 14 lbs. of brewers' grain and 1 lb. of cottonseed meal. In this case 20.58 lbs. of organic matter is fed, containing 2.85 lbs. of protein, 10.38 lbs. of carbohydrates, and 1 lb. of fat. This ration would contain the nutrients in the ratio of 1:4.5. If this ration is considered too narrow, it could be widened to good advantage by feeding with it a small amount of coarse, dry fodder, rather than by increasing the amount of cactus.

A balanced ration of cotton seed meal and cactus cannot be prepared, for if the meal be fed in just sufficient quantity to furnish the proteids, it would necessitate the feeding of too much cactus to supply the balance of the carbohydrates. From this it must not be inferred that a mixture of these foods would not make a desirable ration, in fact current successful practice has demonstrated that they will. For example, a ration of prickly pear and cotton seed meal were fed to steers for 105 days, in a recent experiment conducted by the Bureau of Plant Industry at Encinal, Texas, with a gain of  $1\frac{1}{2}$  lbs. of flesh per day at a cost of only  $3\frac{1}{2}$  cents. However, any ration of these two foods that would secure this gain per day would contain an excess of the proteids over an amount necessary for a balanced ration. Fortunately, however, an excess of proteids can be utilized in serving the functions of the carbohydrates in the animal body, and this no doubt is what took place in the above experiment. Usually proteids are the most expensive foods for man and beast, and it is poor economy to substitute them for carbohydrates, yet

such a condition is not uncommon in Texas cattle feeding where cotton seed meal is cheaper than other more starchy foods.

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### POPULAR NAMES

Some popular names are here used which are rarely, if ever, found in the literature of any language and, therefore, may be strange to the American reader. Special attention has been given to this feature and it is believed that we have been successful in securing these names for which there is a large use. We wish to emphasize that the popular names here given belong to the localities where the particular sample with which they are associated was collected. Some of these plants may have different names in other localities. A complete discussion of this topic, however, requires the employment of a larger list of Mexican species than is here used and we therefore put off further treatment of it for another publication now in course of preparation. These names will assist in the identification of our material and also be of scientific assistance to the student of prickly pears.

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### SCIENTIFIC NAMES

In a group of plants wherein variations are so extreme, proposed names so numerous, scientific evidence of the bases of authors' conceptions of specific distinctions so rare and fragmentary and characterizations so difficult of expression, it is not surprising that there are forms and species to which we hesitate to apply names. Our intention throughout has been to represent our exact conceptions together with notes upon such data as was at hand. Wherever there is a question in our minds about the determinations the same is clearly indicated. Concerning the Engelman species, which are very largely United States forms, we have no hesitancy in pronouncing our determinations correct, except in a few cases where doubt is expressed.

Inasmuch as many of the forms are poorly described a

rather full set of notes accompanies each of our species. These, which are entirely compiled from field records made beside the plants while the specimens were being collected, elaborated and perfected by subsequent observations, are not presented as full technical descriptions but simply as notes or partial descriptions which will be of assistance in the identification of our material. Nearly every number analyzed is represented in collections by one or more specimens secured at the same time or a year later from the same identical locality. Accompanying these are many photographs of the same plants which, together with our field notes and living specimens in conservatories or one or more of the five plantations maintained by the U. S. Department of Agriculture will render the identification of our material in the future comparatively simple. A special effort has been made somewhere in connection with the discussion of every species to refer to a published illustration where such was available and where the illustration was of such a nature as to leave no doubt regarding its identity with the specimen under discussion. We believe that it is by the liberal use of illustrations that order can be brought out of the chaos which exists in this genus. There is no one who can take isolated herbarium specimens in this group and correctly refer them to their proper species, and it is very doubtful whether any one will ever be able to do so because characters do not preserve perfectly in this genus, and there is a lack of constancy anyway which makes it imperative for one to have in mind a large number of characters of nearly every species. These conceptions often must be assisted by geographical distribution in order to enable one to arrive at conclusions. One of the greatest difficulties in the way of properly correlating literature with the species as they occur is due to the lack of proper designation of origin of specimens described, and this practice has not yet closed. Were the origin of materials known, the correlation of the literature with the plants would not be so entirely hopeless.

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### CLIMATIC REQUIREMENTS OF PRICKLY PEARS

Prickly pear and other cacti are apparently inseparably connected in the public mind with drouth and heat but this conception of the requirements for their best development is far from perfect. Our driest deserts produce none of these plants in economic quantities and the same is true of our hottest regions. Rather than say they are adapted to conditions of extreme heat and drouth, we would say that they thrive best in a region which has an equitable temperature and a considerable rainfall periodically distributed. There is certainly no region in the world where these plants grow naturally in such profusion as they do upon the plateau of Mexico, but this is not a hot country, neither is it excessively dry. It is very dry during a large part of the year. It is a desert as compared with eastern Texas, for instance, but it has a considerable rainfall during an average year. This falls mostly in the summer and then the country looks like anything but a desert. The average rainfall at Zacatecas for the past ten years, we are informed by Mr. Albert L. de Lautreppe, who has made a special study of the weather records of the City in connection with a business venture, is  $31\frac{1}{2}$  inches but the average for the seasons January to April and October to December is only  $\frac{3}{8}$  to  $2\frac{1}{8}$  inches, while the average for the other months of the year is  $3\frac{1}{2}$  to  $7\frac{1}{8}$  inches a month. June, July and August are the rainy months, which have had an average rainfall of  $4\frac{1}{2}$  to  $7\frac{1}{8}$  inches each for the past ten years.

While many species appear to be able to withstand high temperatures, they develop naturally in the greatest profusion where the heat is not excessive. The plateau of Mexico is a region with a comparatively equitable climate. Some species thrive under extremes of heat. *O. lindheimeri* is at home in the lower Rio Grande Valley of Texas and Chihuahua and the closely related *O. engelmanni* and *O. engelmanni cycloides* thrive in southern Arizona where the mercury often reaches  $44^{\circ}$  C. On the other hand, there are species which grow

where the winter temperatures go at least to  $-40^{\circ}$  C. but the plants are small and of no economic account in themselves except as they may be used to engraft hardy characters upon more valuable species. The valuable species of the Mexican highlands thrive where the temperature gets down to  $-10^{\circ}$  C. in very rare instances. Usually the freezing point is seldom reached here. During the past winter (1905-6) the mercury dropped at the City of Zacatecas to  $-10^{\circ}$  C. and many of the more delicate spineless forms as well as some of the native species were badly injured. No pear was killed outright but the branches were frozen down for four or more joints. These rotted and dropped off but the old trunks survived. *Opuntia lindheimeri*, the common species of southern Texas, has been injured very severely within the memory of the present generation. It suffered some injury during the winter of 1904-5. In the vicinity of San Antonio many of the plants drooped badly after the coldest weather which registered a temperature of  $-11^{\circ}$  C. The majority of the plants straightened up again but in many the distal joints dropped off as the result of freezing.

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### THE USE OF PRICKLY PEAR IN MEXICO

In Mexico the use of the prickly pear is much more varied than in this country. There the established plantations are guarded from animal depredations by either rude fences or hedges of some of the tall columnar species of *Cereus* or the more spiny opuntias are planted thickly in borders around the more nearly spineless ones which stock eat readily.

All of the species are fed to stock indiscriminately. Whatever is available and can be spared is singed and fed to cattle. So far as we have observed, the Durasnillo is preferred to all others. This is due to some extent to its small fiber content but more especially to its abundant delicate spines which are singed off more readily than those of other species, although they may be fewer in number.

However, the extent of cattle feeding upon this kind of food

is not so great in Mexico as one would suppose from the abundance of the material and the great extent of time during which the practice has been in vogue. The fact is that the average peon cannot afford to feed to stock what he himself can use so profitably in other ways. The prickly pear is to the peon primarily an article of human food and its place cannot be taken by any other plant.

The fruit as well as the young joints are eaten by man in Mexico and the dried stems and joints are used for fuel. Of course, the fuel which it makes is exceedingly poor but it serves the purpose in that land where this commodity is exceedingly scarce. The feeding of cacti to stock, therefore, is a secondary consideration. The limbs which break off and such other portions of the orchard material as can be spared without seriously jeopardizing the tuna crop, together with such wild forms as are available, are fed to cattle. On some of the large haciendas, especially those devoted largely to maguay culture, the feeding of pear to work oxen during the grassless season is a regular practice but then only wild forms are used. Over a large part of the Republic, therefore, although a large use is made of them for forage, their principal use is as an article of human food, which feature will be treated of in a future publication.

## THE SPECIES AND THEIR ANALYSIS

Prickly Pears (*Platopuntia*.)

Nos. 6329, 6330, 6542, 7571 and 7572.

## PRICKLY PEAR. NOPAL.

*Opuntia Lindheimeri* Engelm. *Boston Jour. Nat. Hist.* 6: 207. 1850.

An erect or sometimes ascending plant, 3 to 5 feet high, growing in isolated individuals or forming impenetrable thickets; joints mostly obovate but very variable, commonly 5-8 in. x 7-9 in., smooth, yellowish green to glaucous; areoles circular to obovate,  $\frac{1}{8}$  to  $\frac{1}{2}$  in. in greatest diameter but increasing in size with age, about 1 in. apart; wool tawny, black where exposed; spicules yellow to grayish-white, prominent,  $\frac{1}{2}$  in. long or sometimes inconspicuous; spines yellow, translucent, faintly anulate, flattened and often a little twisted, erect, divergent or lower often somewhat recurved, 1 to 6 but usually 3 or 4 in number,  $\frac{1}{4}$  to  $2\frac{1}{4}$  in. long but commonly about 1 in.; flowers yellow with greenish style and filaments and bright, deep green, 8-parted stigma, with long cylindrical segments; fruits pyriform, about  $1\frac{1}{2}$  x  $2\frac{1}{2}$  in., purple throughout, with small, subcircular to triangular areoles about  $\frac{1}{2}$  in. apart.

This description applies to the form from which samples were taken and is not intended to cover the many variations of the species as recognized by recent authors.<sup>1</sup> These specimens represent our conception of the typical form of the species. Photographic reproductions will be found in Bull. 74 Pl. 1, f. 2, Pl. 2, f. 1 and Pl. 4, f. 2, Bureau of Plant Industry U. S. D. A.

No. 6329 collected at Eagle Pass, Texas, May 10, 1904, sample consisting of five terminal joints and three partially developed fruits, from 4 plants.

No. 6330 collected at same time and place and from same plants as No. 6329, sample consisting of a small section 3 in. long, cut from old stems near the ground.

No. 6542 collected at Pearsall, Texas, June 15, 1904, sample consisting of fruits from 11 plants. These are the first fruits to mature this season.

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1. See Bulletin 91, Bureau of Animal Industry, U. S. D. A.

**PLATE II.—NOPAL CUIJO.**



**Fig. 1. A medium sized plant growing near San Luis Potosi, Mexico.**



**Fig. 2. Joint of the same plant in bud.**

PLATE III.--TWO GENERA OF PRICKLY PEAR.



Fig. 1. *Nopalea* Sp.



Fig. 2. (*Opuntia occidentalis*) Engelm. and Bigel.

**PLATE IV.—NOPAL DURASNILLO (*Opuntia leuotricha*) P. D. C.**



**Fig. 1. Nopal durasnillo blanco.**



**Fig. 2. Nopal durasnillo colorado.**

PLATE V.



Fig. 1. Nopal Tapon (*Opuntia robusta* Wendl). A very robust plant, compare Bulletin 74, Plate V, Fig. 1, B. P. I., U. S. Department of Agriculture. Soledad, Mexico.



Fig. 2. Nopal de Castilla (No. 7519), as grazed by cattle. Laredo, Tex.



No. 7571 collected at Encinal, Texas, February 26, 1905, sample consisting of 4 terminal joints from 3 plants.

No. 7572 collected at same time and from same plants as No. 7571, sample represented by formula 0-0-0-0-1-1-1.

### Chemical Analyses

|                         | Green. |       |              |       |       | Air Dry. |       |              |       |       |
|-------------------------|--------|-------|--------------|-------|-------|----------|-------|--------------|-------|-------|
|                         |        |       | <sup>1</sup> |       |       |          |       | <sup>1</sup> |       |       |
| Sample No.....          | 63.29  | 63.80 | 65.42        | 75.71 | 75.72 | 63.29    | 63.80 | 65.42        | 75.71 | 75.72 |
| Spines .....            | .76    | .58   |              |       |       | 3.73     | 2.51  |              |       |       |
| Water .....             | 80.72  | 77.95 | 92.19        | 88.64 | 84.49 | 5.33     | 5.14  | 4.85         | 7.08  | 6.35  |
| Ash .....               | 4.44   | 5.81  | 1.69         | 1.64  | 2.42  | 21.78    | 25.00 | 13.23        | 13.40 | 14.60 |
| Crude Protein.....      | 1.88   | .92   | .65          | .55   | .36   | 6.79     | 3.64  | 7.88         | 4.49  | 2.19  |
| Crude Fat .....         | .42    | .41   | .49          | .29   | .27   | 2.06     | 1.78  | 5.95         | 2.40  | 1.65  |
| Nitrogen Free Extract.. | 10.87  | 11.58 | 2.85         | 7.72  | 8.80  | 53.37    | 49.81 | 34.89        | 63.15 | 53.18 |
| Crude Fiber .....       | 2.17   | 3.33  | 2.73         | 1.16  | 3.65  | 10.65    | 14.33 | 33.20        | 9.53  | 22.03 |
| Organic Matter.....     | 14.84  | 16.24 | 6.72         | 9.72  | 13.08 | 72.89    | 69.86 | 81.92        | 79.57 | 79.05 |

<sup>1</sup> Fruit.

Nos. 7515, 7516 and 7567.

### PRICKLY PEAR. NOPAL, NOPAL AZUL, BLUE PEAR

OPUNTIA LINDHEIMERI *Engelm. Boston Jour. Nat. Hist.* 6:207. 1850.

This is a brown-spined form and differs from the typical species in having fewer spines and darker colored orange instead of yellow flowers. The joints are also on an average a somewhat darker glaucous green. Modern botanical practice scarcely admits this into the same species as the previous one, although it has commonly been placed there in the past.

No. 7515 collected at Encinal, Texas, January 17, 1905, sample represented by formula 2-1-1, from three plants.

No. 7516 collected at same time and place and from same plants as No. 7515, sample consisting of 3 pieces from old stems near the ground.

No. 7567 collected at San Antonio, Texas, February 23, 1905, sample represented by formula 1-1-0-1, from 3 plants.

## Chemical Analyses

|                       | GREEN |       |       | AIR DRY |       |       |
|-----------------------|-------|-------|-------|---------|-------|-------|
| Sample No.            | 7515  | 7516  | 7567  | 7515    | 7516  | 7567  |
| Spines                | .10   |       | .42   | .72     |       | 2.60  |
| Water                 | 87.36 | 79.88 | 84.82 | 5.65    | 5.20  | 6.55  |
| Ash                   | 2.82  | 4.98  | 2.27  | 21.05   | 23.45 | 13.95 |
| Crude Protein         | .60   | .45   | .96   | 4.49    | 2.12  | 5.92  |
| Crude Fat             | .26   | .20   | .30   | 1.95    | .96   | 1.82  |
| Nitrogen Free Extract | 7.54  | 9.55  | 9.84  | 56.26   | 44.98 | 60.61 |
| Crude Fiber           | 1.42  | 4.94  | 1.81  | 10.60   | 23.30 | 11.15 |
| Organic Matter        | 9.82  | 15.14 | 12.91 | 73.30   | 71.35 | 79.50 |

## Analyses of the Ash

| Sample No. | Carbon, per cent. | Sand, per cent. | PER CENT. IN PURE ASH             |           |               |                |              |                |               |             |                               |                              |               |                             |
|------------|-------------------|-----------------|-----------------------------------|-----------|---------------|----------------|--------------|----------------|---------------|-------------|-------------------------------|------------------------------|---------------|-----------------------------|
|            |                   |                 | SolubleSilica (SiO <sup>3</sup> ) | Iron (Fe) | Aluminum (Al) | Manganese (Mn) | Calcium (Ca) | Magnesium (Mg) | Potassium (K) | Sodium (Na) | Phosphoric Acid radicle (PO4) | Sulphuric Acid radicle (SO4) | Chlorine (Cl) | Carbonic Acid radicle (CO3) |
| 7515       | .14               | .29             | .43                               | .20       | 0.00          | .49            | 26.71        | 2.27           | 14.23         | .35         | 1.11                          | 1.15                         | 2.15          | 49.13                       |

Nos. 6243, 7011 and 7787.

## PRICKLY PEAR. NOPAL

OPUNTIA ENGELMANNI *Salm. Bost. Jour. Nat. Hist.*  
6:207. 1850.

A suberect plant about 3 feet high, growing in dense thickets or in isolate dindividuals 3 to 5 feet in diameter; joints obovate in proportion of 5 to 8 in., which is a common size, rather light yellow, glossy green but glaucous until after the first winter, usually scurfy brown in age; leaves subulate, mucronate,  $\frac{3}{8}$  x 3-32 in., areoles subcircular, prominent,  $\frac{1}{8}$  in. in diam., but increasing in size with age; wool gray but dirty brown where exposed; spicules often yellow and brown on

same plant but mostly yellow,  $\frac{1}{2}$  in. long on sides of joints but often becoming  $\frac{1}{2}$  to 1 in. long on edges and increasing wonderfully with age, in many cases becoming a solid spreading mass filling a  $\frac{1}{2}$  in. areole; spines very variable, yellow to white but always with translucent yellowish tips, 1 to 3 or 4, slanting downward or erect spreading, very variable,  $\frac{1}{2}$  to  $1\frac{1}{2}$  in. in length; flowers yellow with style and filaments greenish-white and stigma bright dark green; fruits obovate,  $1\frac{1}{2}$  to  $1\frac{3}{4}$  x  $2\frac{1}{2}$  to  $2\frac{3}{4}$  in., beset with prominent subcircular to triangular areoles about  $\frac{1}{2}$  in. apart, bearing formidable yellow spicules, light reddish-purple without but rind and pulp greenish and brittle when mature.

This differs very much in general appearance from the typical form of *Opuntia lindheimeri*, with which it has been commonly placed by recent botanists, but the difference is one of general appearance mostly. This is a smaller and more spiny plant throughout. The most important distinction is in the fruit but *O. lindheimeri* also has fruits with greenish pulp and rind.<sup>1</sup>

No. 6243 collected in Santa Rita Mountains, Arizona, April 30, 1904, sample represented by formula 3-3-2, from 3 plants.

No. 7011 collected from same plants as No. 6243, August 30, 1904, sample consisting of fruits from 10 plants.

No. 7787 collected from the same group of plants as previous numbers April 19, 1905, sample represented by formula 1-2-1, from 3 plants.

1. See Bulletin 91, Bureau of Animal Industry, U. S. D. A.

#### Chemical Analyses

| Sample No. ....            | Green. |       |       | Air Dry. |       |       |
|----------------------------|--------|-------|-------|----------|-------|-------|
|                            | 6243   | 7011  | 7787  | 6243     | 7011  | 7787  |
| Spines .....               |        |       | .26   |          |       | 1.94  |
| Water.....                 | 79.05  | 85.70 | 87.36 | 5.93     | 2.35  | 6.12  |
| Ash.....                   | 3.56   | 1.00  | 1.83  | 16.00    | 6.80  | 13.63 |
| Crude Protein.....         | 1.10   | .67   | .59   | 4.92     | 4.00  | 4.42  |
| Crude Fat.....             | .36    | .84   | .21   | 1.60     | 5.73  | 1.59  |
| Nitrogen Free Extract..... | 13.81  | 7.91  | 8.32  | 62.05    | 54.02 | 61.66 |
| Crude Fiber.....           | 2.12   | 3.88  | 1.69  | 9.50     | 26.50 | 12.58 |
| Organic Matter.....        | 17.39  | 13.30 | 10.81 | 78.07    | 90.85 | 80.25 |

1 Fruit.

Nos. 6240 and 7774.

**PRICKLY PEAR. NOPAL**

*Opuntia Engelmannii* Salm. *Boston Jour. Nat. Hist.* 6: 208, 1850.

A large, erect or ascending plant 3 to 5 feet high; joints obovate to subcircular, large in proportion of 6 to  $6\frac{1}{2}$  x 10 in., which is a common size, usually more or less glaucous, with a waxy covering; areoles obovate-triangular, prominent, large  $\frac{1}{4}$  x  $\frac{3}{4}$ -16 in., increasing in size with age and becoming very prominent upon old stems; wool very prominent; brownish on surface but white beneath; spicules brown, prominent, mixed with the wool but more prominent on edges of areole, often  $\frac{1}{2}$  in. long on edges of joints; spines yellowish white, with often a tinge of red at base,  $\frac{1}{4}$  to 1 in. long, strong flattened, 1 to 4 or 5, increasing slightly with age, erect, divergent, or often descending; petals yellow, stigma deep dark green, style and filaments greenish white; fruit obovate,  $1\frac{1}{2}$  to  $2\frac{1}{2}$  in., flat or depressed at apex, with light red epidermis and greenish pulp and pericarp.

The rind of this species agrees with previous one in color but differs from it in texture. When fully ripened it is brittle and appears to differ but little in either flavor or texture from the pulp, from which it is easily separable. In this respect it resembles more closely than any other species some of the various forms of what passes for *O. phaeacantha*, but it will be seen from the descriptions that it is very different from that species. It is quite probable that these numbers and the previous ones are the same species but that the differences are simply varietal. These are from a cañon at the base of the mountains while the previous numbers are from a cañon about five miles below in the lower foothills. These are much more robust plants.

No. 6240 collected in Santa Rita Mountains, Arizona, April 29, 1904, sample represented by formula 1-2-1, from 2 plants.

No. 7774 collected from the same plants April 18, 1905, sample represented by formula 1-1-0-1, from 3 plants.

## Chemical Analyses

|                            | Green. |       | Air Dry. |       |
|----------------------------|--------|-------|----------|-------|
|                            | 6240   | 7774  | 6240     | 7774  |
| Sample No.....             | 6240   | 7774  | 6240     | 7774  |
| Spines.....                |        | .07   |          | .45   |
| Water.....                 | 72.60  | 86.19 | 4.13     | 5.43  |
| Ash.....                   | 6.94   | 2.90  | 24.30    | 19.83 |
| Crude Protein.....         | .81    | .63   | 2.95     | 4.34  |
| Crude Fat.....             | .41    | .19   | 1.43     | 1.28  |
| Nitrogen Free Extract..... | 15.37  | 8.66  | 53.77    | 59.88 |
| Crude Fiber.....           | 3.84   | 1.43  | 13.42    | 9.79  |
| Organic Matter.....        | 20.46  | 10.91 | 71.57    | 74.74 |

## Analyses of the Ash

| Sample No. | Per cent. Carbon | Per cent. Sand | Per Cent. Pure Ash.                |           |               |                |              |                |               |             |                                            |                                           |               |                                          |
|------------|------------------|----------------|------------------------------------|-----------|---------------|----------------|--------------|----------------|---------------|-------------|--------------------------------------------|-------------------------------------------|---------------|------------------------------------------|
|            |                  |                | Soluble Silica (SiO <sub>2</sub> ) | Iron (Fe) | Aluminum (Al) | Manganese (Mn) | Calcium (Ca) | Magnesium (Mg) | Potassium (K) | Sodium (Na) | Phosphoric Acid radicle (PO <sub>4</sub> ) | Sulphuric Acid radicle (SO <sub>4</sub> ) | Chlorine (Cl) | Carbonic Acid radicle (CO <sub>2</sub> ) |
| 7774       | .25              | .28            | 1.41                               | .20       | .12           | .51            | 27.39        | 6.20           | 8.01          | .19         | 1.35                                       | 1.13                                      | .68           | 47.96                                    |

Nos. 6692 and 7890.

## PRICKLY PEAR. NOPAL

*Opuntia Engelmannii* (?) Salm. *Bost. Jour. Hist.* 6: 207. 1850.

These specimens correspond quite closely with the typical form of *Opuntia engelmannii* and are one of the forms included under *O. lindheimeri* Engelm. by recent monographers (Coulter and Schumann). Small thickets are formed by it here upon gentle slopes comparatively free from rocks. It shows a slight tendency to have areoles which develop like *O. chlorotica*, although to a much less degree.

No. 6692 collected at Hackberry, Arizona, July 25, 1904, sample represented by formula 2-1-1-1, from 4 plants.

No. 7890 collected in same locality May 9, 1905, sample represented by formula  $\frac{1}{2}$ -2-2- $\frac{1}{2}$ , from 4 plants.

#### Chemical Analyses

| Sample No.....             | Green. |       | Air Dry. |       |
|----------------------------|--------|-------|----------|-------|
|                            | 66.92  | 78.90 | 66.92    | 78.90 |
| Spines.....                | .85    | .15   | 1.70     | .90   |
| Water.....                 | 81.65  | 85.75 | 9.85     | 6.45  |
| Ash.....                   | 4.25   | 3.27  | 20.90    | 21.53 |
| Crude Protein.....         | .89    | .45   | 4.37     | 2.96  |
| Crude Fat.....             | .32    | .39   | 1.55     | 2.53  |
| Nitrogen Free Extract..... | 10.84  | 8.34  | 53.26    | 54.73 |
| Crude Fiber.....           | 2.05   | 1.80  | 10.07    | 11.80 |
| Organic Matter.....        | 14.10  | 10.98 | 69.25    | 72.12 |

Nos. 6247 and 7790 D. G and 3002, 3073a and 3073b E. O. W.

#### PRICKLY PEAR. NOPAL

OPUNTIA ENGELMANII CYCLOIDES (?) *Engelm. and Bigel. Pacific Ry. Rep. 4: 37. Pl. 8, f. 1. 1856.*

Plant 3 to 5 feet high, erect, large and stout; joints sub-orbicular, commonly 10x11 in., glaucous, thick; leaves nearly  $\frac{1}{2}$  in. long and  $\frac{1}{2}$  in. wide, subulate, cuspidate, upon conspicuous tubercles which disappear with growth of joint; areoles 1 to 1 $\frac{1}{4}$  in. apart, large and prominent, oval to circular,  $\frac{1}{4}$  to  $\frac{3}{8}$  in. in longest diam. with a bunch of dirty brown wool projecting 1-16 to  $\frac{1}{2}$  in. above surface of joint; spicules yellow, inconspicuous, except upon margin of joints, where they are unequal,  $\frac{1}{4}$  to  $\frac{3}{8}$  in. long; spines white with a pinkish blush at base and bone-like, translucent tips, stout, erect, divergent, strongly flattened, 1 to 6 in number, commonly 1 in. or less in length; flowers yellow with orange at base of petals and bright green, 8-parted stigma; fruit obovate, about 1 $\frac{1}{2}$ x2 in. reddish purple throughout, with prominent, circular areoles about  $\frac{1}{4}$  in. apart.

It will be seen that our description of the fruit varies somewhat from that of Dr. Engelmann<sup>1</sup>. The only fruit we have seen from our plants is a few developed in the U. S.

1. Pacific Railway Report 4: 37. Pl. 8, f. 1. 1856.

Department of Agriculture greenhouse the first year from cuttings. The habit of the plant is fairly well shown in Bull. 67, *Pl. 6, f. 1*, Bureau of Plant Industry, U. S. D. A.

No. 6247 collected in northern foothills of Santa Rita Mountains, Arizona, May 2, 1904, sample represented by formula 2-2-1, from 3 plants.

No. 7790 collected from same plants April 20, 1905, sample represented by formula 1-1-1.

No. 3002 E. O. W. collected east of Hillsboro, New Mexico, July 12, 1904, sample consisting of joints.

No. 3073a E. O. W. collected in Organ Mountains, New Mexico, January 31, 1905, sample consisting of last year's joints.

No. 3073b E. O. W. collected at same time and from same plants as 3073a, sample consisting of joints and one year older than 3073a.

#### Chemical Analyses

| Sample No.....          | Green. |       |       |       |       | Air Dry. |       |       |       |       |
|-------------------------|--------|-------|-------|-------|-------|----------|-------|-------|-------|-------|
|                         | 6247   | 7790  | 3002  | 3073a | 3073b | 6247     | 7790  | 3002  | 3073a | 3073b |
| Spines.....             |        | .34   | 2.17  | .55   | .27   | .....    | 1.59  | ..... | 1.64  | 1.27  |
| Water.....              | 81.94  | 79.69 | 66.67 | 68.02 | 79.34 | 4.15     | 5.46  | 3.65  | 5.63  | 5.46  |
| Ash.....                | 3.82   | 4.48  | 8.29  | 3.67  | 3.08  | 20.28    | 20.85 | 23.30 | 10.85 | 14.10 |
| Crude Protein.....      | .37    | .64   | 1.31  | 2.41  | .98   | 1.97     | 2.96  | 3.39  | 7.12  | 4.49  |
| Crude Fat.....          | .22    | .33   | .69   | .26   | .27   | 1.15     | 1.54  | 1.95  | .76   | 1.22  |
| Nitrogen Free Extract.. | 7.74   | 11.93 | 19.25 | 22.03 | 18.46 | 41.10    | 55.52 | 54.08 | 65.01 | 61.58 |
| Crude Fiber.....        | 5.91   | 2.93  | 3.89  | 3.60  | 2.87  | 31.35    | 13.67 | 10.93 | 10.63 | 13.15 |
| Organic Matter.....     | 14.24  | 15.83 | 25.04 | 28.30 | 17.58 | 75.57    | 73.69 | 70.35 | 83.52 | 80.44 |

## Analyses of the Ash

| Sample No. | Per Cent. Carbon | Per Cent. Sand | Per Cent. in Pure Ash. |           |               |                |              |                |               |             |                               |                              |               |                             |
|------------|------------------|----------------|------------------------|-----------|---------------|----------------|--------------|----------------|---------------|-------------|-------------------------------|------------------------------|---------------|-----------------------------|
|            |                  |                | Soluble Silica (SiO3)  | Iron (Fe) | Aluminum (Al) | Manganese (Mn) | Calcium (Ca) | Magnesium (Mg) | Potassium (K) | Sodium (Na) | Phosphoric Acid radicle (PO4) | Sulphuric Acid radicle (SO4) | Chlorine (Cl) | Carbonic Acid radicle (CO3) |
| 7790       | .59              | .73            | 1.25                   | .15       | .15           | .77            | 33.90        | 3.00           | 4.28          | .13         | .61                           | .97                          | .43           | 53.82                       |
| 3002       | .81              | .60            | .84                    | .25       | .27           | .26            | 26.10        | 6.06           | 12.71         | .22         | 1.37                          | .80                          | .30           | 44.74                       |

Nos. 6248 and 7791.

## PRICKLY PEAR. NOPAL

*Opuntia Engelmannii* Cycloides *Engelm. and Bigel. Pacif. Ry. Rep. 4: 37. Pl. 8. f. 1. 1856.*

The general aspect of these plants is somewhat different from that of the previous numbers. The main difference is in the spines, which are often  $2\frac{1}{2}$  in. long, decidedly red at the base and quite decidedly recurved. The spicules are, as a rule, more abundantly developed and the joints average smaller and are more inclined to be obovate. We consider these numbers to be typical of the variety but the shape of the joints often does not correspond with the published descriptions although in general they do. The majority of our specimens agree perfectly with the type<sup>1</sup> in the Engelmann herbarium.

No. 6248 collected in Santa Rita Mountains, Arizona, May 2, 1904, growing with No. 6247, sample represented by formula 2-1 $\frac{1}{2}$ -1, from 3 plants.

No. 7791 collected from same plants, April 20, 1905, sample represented by formula 1-1-1, from 3 plants.

1. Bigelow of 1853 in Herb. Mo. Bot. Gard.



## Chemical Analyses

| Sample No.                  | Green |       | Air Dry. |       |
|-----------------------------|-------|-------|----------|-------|
|                             |       |       |          |       |
| Sample No. ....             | 62.48 | 77.91 | 62.48    | 77.91 |
| Spines .....                |       | .49   |          | 2.44  |
| Water .....                 | 72.65 | 81.00 | 5.80     | 5.78  |
| Ash .....                   | 5.96  | 4.32  | 20.55    | 21.43 |
| Crude Protein .....         | .79   | .62   | 2.73     | 3.07  |
| Crude Fat .....             | .41   | .36   | 1.43     | 1.86  |
| Nitrogen Free Extract ..... | 16.79 | 11.54 | 57.75    | 57.21 |
| Crude Fiber .....           | 3.40  | 2.16  | 11.74    | 10.71 |
| Organic Matter .....        | 21.39 | 14.68 | 73.65    | 72.79 |

## Analyses of the Ash

| Sample No. | Per Cent. Carbon | Per Cent. Sand | Per Cent in Pure Ash.                 |           |               |                |              |                |               |             |                                               |                                              |               |                                             |
|------------|------------------|----------------|---------------------------------------|-----------|---------------|----------------|--------------|----------------|---------------|-------------|-----------------------------------------------|----------------------------------------------|---------------|---------------------------------------------|
|            |                  |                | Soluble Silica<br>(SiO <sub>2</sub> ) | Iron (Fe) | Aluminum (Al) | Manganese (Mn) | Calcium (Ca) | Magnesium (Mg) | Potassium (K) | Sodium (Na) | Phosphoric acid<br>radicle (PO <sub>4</sub> ) | Sulphuric acid<br>radicle (SO <sub>4</sub> ) | Chlorine (Cl) | Carbonic acid<br>radicle (CO <sub>2</sub> ) |
| 77.91      | .45              | .95            | 1.29                                  | .15       | .26           | .19            | 32.76        | 3.43           | 5.38          | .23         | .52                                           | .85                                          | .62           | 53.86                                       |

Nos. 6564 and 7854.

## PRICKLY PEAR. NOPAL.

OPUNTIA OCCIDENTALIS *Engelm. and Bigel. Pacif. Ry.*  
*Rep 4: 38. Pl. 7, f. 1-2. 1856.*

An erect, open branching species, 4 to 8 feet high, commonly in thickets upon southern exposures, but also growing in scattering individuals; joints ovate, pointed to obovate or subcircular, yellowish-green; areoles subcircular or obovate-triangular, large and prominent, about 1 to 1½ in. apart; spicules yellow, very unequal and formidable, varying in length from ¼ to 1-16 in. in same areole; spines yellow, translucent, often with reddish-brown bases when young, flattened, twisted, erect-divergent or lower recurved, 3 to 7,

about 1 in. long; flowers orange, red where exposed in bud, with filaments orange, style reddish with deep, bright green, 8-parted stigma; fruit obovate, pyriform, purplish-red throughout.

Of late this species has been referred quite constantly to *O. Lindheimeri* but we consider it wiser to retain the original name as given above until the different forms which have been heretofore placed under *O. Lindheimeri* have been brought together under cultivation so that there may be a basis for comparison, which we now have not. This is certainly distinct from *O. Lindheimeri*.

No. 6564 collected at San Diego, Cal., June 30, 1904, sample represented by formula 1-1-1-1, from 3 plants.

No 7854 collected in same locality May 4, 1905, sample represented by formula  $\frac{1}{2}$ -2-2- $\frac{1}{2}$ , from 4 plants.

#### Chemical Analyses

| Sample No.....             | Green. |       | Air Dry. |       |
|----------------------------|--------|-------|----------|-------|
|                            | 6564   | 7854  | 6564     | 7854  |
| Spines.....                | .34    | .48   | 3.25     | 4.11  |
| Water.....                 | 89.57  | 89.05 | 7.38     | 7.48  |
| Ash.....                   | 1.96   | 1.10  | 18.80    | 9.85  |
| Crude Protein.....         | .35    | .47   | 3.39     | 4.01  |
| Crude Fat.....             | .15    | .19   | 1.48     | 1.60  |
| Nitrogen Free Extract..... | 5.84   | 7.89  | 55.97    | 66.66 |
| Crude Fiber.....           | 1.36   | 1.30  | 12.98    | 10.90 |
| Organic Matter.....        | 7.70   | 9.85  | 73.82    | 83.17 |

Nos. 6567 and 7863.

#### PRICKLY PEAR. NOPAL.

*Opuntia Occidentalis* Engelm. and Bigel. *Pacific Ry. Rep.* 4: 38. Pl. 7, f. 1-2. 1856.

The previous numbers we consider typical of the plant described by Dr. Engelmann under this name, indeed some of our specimens could easily be substituted for the type. This one differs very little in any essential particular but it is very peculiar in one respect. Both this and the previous

number are very spiny, as a rule, but often one-half of the joints in this form may be smooth or with only a few of the areoles at apex bearing spines. The areoles on these joints are reduced in size and both spicules and spines may be entirely absent. There is also apparently a stronger tendency for the young spines to be red at the base and to turn chalky earlier than in the other form. The joints also average longer and narrower in these specimens than in the previous numbers. (See *Pl. III. f. 2.*)

No. 6567 collected at San Diego, Cal., July 1, 1904, sample represented by formula 3-2-1-1-1, from 4 plants.

No. 7863 collected in same locality May 4, 1905, sample represented by formula  $\frac{1}{2}$ -1 $\frac{1}{2}$ -1 $\frac{1}{2}$ , from 4 plants.

#### Chemical Analyses

| Sample No.....             | Green. |       | Air Dry. |       |
|----------------------------|--------|-------|----------|-------|
|                            | 6567   | 7863  | 6567     | 7863  |
| Spines.....                | .62    | .35   | 1.89     | 2.99  |
| Water.....                 | 70.19  | 89.06 | 8.60     | 6.63  |
| Ash.....                   | 5.82   | 1.45  | 17.85    | 12.49 |
| Crude Protein.....         | 1.07   | .45   | 3.29     | 3.83  |
| Crude Fat.....             | .49    | .17   | 1.50     | 1.45  |
| Nitrogen Free Extract..... | 16.43  | 6.44  | 50.36    | 54.80 |
| Crude Fiber.....           | 6.00   | 2.44  | 18.40    | 20.80 |
| Organic Matter.....        | 23.99  | 9.53  | 73.55    | 80.88 |

#### No. 7429 D. G. and 3032 E. O. W.

*Opuntia laevis* (?) Coulter *Contr. U. S. Nat. Herb.* 3: 419. 1896.

This is a variety commonly cultivated in the vicinity of Las Cruces, New Mexico, and has been reported to us to have been brought from Chihuahua. In many respects it resembles *Opuntia laevis* Coulter. The locality from which it is reported to have been introduced, the comparatively few spines, the deep purple fruit and the general aspect of the

plant, as we know it from both field and herbarium specimens, suggest Coulter's species very strongly.

No. 7429 D. G. collected from cultivated plants at Las Cruces, New Mexico, October 11, 1904, sample represented by formula 1-2-1, from 2 plants.

No. 3032 E. O. W. collected from cultivated specimens at Mesilla Park, New Mexico, September 12, 1904.

#### Chemical Analyses

| Sample No.....             | Green |       | Air Dry |       |
|----------------------------|-------|-------|---------|-------|
|                            | 7429  | 3032  | 7429    | 3032  |
| Spines.....                | .80   | .14   | 7.87    | 2.10  |
| Water.....                 | 90.11 | 93.80 | 2.80    | 8.43  |
| Ash.....                   | 2.66  | 1.62  | 26.18   | 23.60 |
| Crude Protein.....         | .62   | .32   | 6.13    | 4.71  |
| Crude Fat.....             | .19   | .12   | 1.88    | 1.85  |
| Nitrogen Free Extract..... | 5.23  | 3.37  | 51.26   | 50.19 |
| Crude Fiber.....           | 1.19  | .77   | 11.75   | 11.20 |
| Organic Matter.....        | 7.23  | 4.58  | 71.02   | 67.95 |

#### Analysee of the Ash

| Sample No. | Per cent. carbon | Per cent. sand | PER CENT. IN PURE ASH               |           |               |                |              |                |               |             |                                            |                                           |               |                                          |
|------------|------------------|----------------|-------------------------------------|-----------|---------------|----------------|--------------|----------------|---------------|-------------|--------------------------------------------|-------------------------------------------|---------------|------------------------------------------|
|            |                  |                | Soluble Silicia (SiO <sub>2</sub> ) | Iron (Fe) | Aluminum (Al) | Manganese (Mn) | Calcium (Ca) | Magnesium (Mg) | Potassium (K) | Sodium (Na) | Phosphoric Acid radicle (PO <sub>4</sub> ) | Sulphuric Acid radicle (SO <sub>4</sub> ) | Chlorine (Cl) | Carbonic Acid radicle (CO <sub>2</sub> ) |
|            |                  |                |                                     |           |               |                |              |                |               |             |                                            |                                           |               |                                          |
| 3032       | 1.12             | 7.00           | 4.06                                | .55       | .46           | .19            | 21.40        | 9.26           | 9.44          | .44         | 2.07                                       | 1.24                                      | 1.18          | 43.76                                    |

Nos. 6534, 6535 and 7596

#### NOPAL CUIJO

*OPUNTIA ENGELMANNI CUIJA n. var.*

An erect, rather closely branched, compact plant, 4 to 5 feet high; joints obovate, ovate, or quite abruptly contracted

below, yellowish-green, commonly  $5\frac{1}{2} \times 6\frac{1}{2}$  in. and  $\frac{3}{4}$  to 7-8 in. thick, but often as large as  $7 \times 10$  in.; areoles subcircular, prominent,  $\frac{1}{8}$  to  $\frac{1}{4}$  in. in diam. and projecting 1-16 to  $\frac{1}{8}$  in. above surface of joint, dark brown to black and weathering to gray,  $1\frac{1}{4}$  to  $1\frac{3}{4}$  in. apart; spicules yellow, more or less surrounding the entire areole and often scattered through it, conspicuous, about  $\frac{1}{8}$  in. long on sides of joints but often 1 in. long on the edges; spines yellow but often red at base, flattened but seldom twisted, very indistinctly annular, 1 to  $1\frac{3}{4}$  in. long, 3 to 8, but mostly 4 to 6, erect-spreading; flowers yellow, with whitish or greenish filaments and style, and a deep bright green, 8 to 10-parted stigma; fruit pyriform, about  $1\frac{1}{4} \times 1\frac{3}{4}$  in., deep purple throughout, almost black when fully matured.

In habit this species corresponds very well with *O. lindheimeri* Engelm. but in general appearance, especially in areoles and color of joints, it differs very much from the typical form of the New Braunfels, Texas region. However, it may be possible that this represents the southern extension of this typically Rio Grande valley species. (See Pl. IV). Number 7636, San Luis Potosi, Mexico, is the botanical type of this species.

No. 6534 collected at San Luis Potosi, Mexico, June 12, 1904, sample consisting of many mature fruits from 9 plants.

No. 6535 collected at same time and place, sample represented by formula 3-2-1, from 4 plants

No. 7596 collected at San Luis Potosi, Mexico, March 13, 1905, sample represented by formula 1-1-1-2, from 3 plants.

#### Chemical Analyses

| Sample No.....             | Green |       |       | Air Dry. |       |       |
|----------------------------|-------|-------|-------|----------|-------|-------|
|                            | 65341 | 6535  | 7596  | 65341    | 6535  | 7596  |
| Spines .....               |       | .82   | .88   |          | 4.40  | 2.94  |
| Water.....                 | 86.00 | 82.67 | 97.76 | 3.28     | 7.40  | 5.08  |
| Ash.....                   | 1.20  | 3.80  | 1.94  | 8.28     | 20.30 | 15.00 |
| Crude Protein.....         | 1.12  | 1.31  | .45   | 7.77     | 7.01  | 3.50  |
| Crude Fat.....             | 1.29  | .40   | .23   | 6.90     | 2.13  | 1.75  |
| Nitrogen Free Extract..... | 5.73  | 8.65  | 8.48  | 39.59    | 46.21 | 65.12 |
| Crude Fiber.....           | 4.66  | 3.17  | 1.14  | 32.18    | 14.95 | 8.85  |
| Organic Matter.....        | 12.80 | 13.53 | 10.30 | 88.44    | 72.30 | 79.92 |

#### 1. Fruit.

## Analyses of the Ash

| Sample No. | Per Cent. Carbon | Per Cent. Sand | Per Cent. in Pure Ash.                |           |               |                |              |                |               |             |                                                             |
|------------|------------------|----------------|---------------------------------------|-----------|---------------|----------------|--------------|----------------|---------------|-------------|-------------------------------------------------------------|
|            |                  |                | Soluble Silica<br>(SiO <sub>2</sub> ) | Iron (Fe) | Aluminum (Al) | Manganese (Mn) | Calcium (Ca) | Magnesium (Mg) | Potassium (K) | Sodium (Na) | Phosphoric Acid<br>radicle (P <sub>2</sub> O <sub>5</sub> ) |
| 65.85      | .49              | 8.27           | 2.30                                  | .93       | .56           | .35            | 23.19        | 4.91           | 13.20         | .54         | 1.13                                                        |
|            |                  |                |                                       |           |               |                |              |                |               |             | 2.10                                                        |
|            |                  |                |                                       |           |               |                |              |                |               |             | 2.30                                                        |
|            |                  |                |                                       |           |               |                |              |                |               |             | 40.13                                                       |

Nos. 6573 and 7876.

## OPUNTIA

Plant ascending, erect, divaricately branched, 2 to 4 feet high, and forming thickets upon steep hillsides; joints obovate, 4 x 6 in. to 5 x 7 in., either bright or glaucous green; leaves about 1-16 x  $\frac{3}{8}$  in., subulate, pointed; areoles  $\frac{1}{4}$  to 1 in. apart, ovate, obovate or subcircular, increasing in size with age; spicules yellow,  $\frac{1}{8}$  in. long, increasing with age to fill entire areole; spines reddish-brown at base and yellow toward tip, turning chalky to dirty black, often chalky throughout, with scarcely a tinge of red, 1 to 5 or 6, usually 3 or 4, erect-divergent, the longest  $\frac{1}{4}$  to 1 in. long, flattened; flowers a light magenta, resembling very closely the well known color of *O. basilaris* with style and filaments pink and 8 to 9-parted, yellowish-green stigma; mature fruit not seen.

It will be seen from the description that this differs in several particulars from the coastal forms of California, with which it has commonly been associated. It differs from No. 6567 (*Opuntia occidentalis* Engelm. and Bigel.) in spine, habit and joint characters but more especially in color of flowers. It differs from *O. littoralis* of the coast, which we consider distinct from *O. occidentalis*, in being erect and having smaller joints as well as in having magenta instead of yellow flowers. Associated with this (No. 6573 and 7876), however, is a yellow flowered form which differs but very little from it in any other character. As a general rule the yellow flowered form has longer, whiter spines but this does not always hold true.

We have had no opportunity of comparing the fruits of this and its yellow flowered associate.

No. 6573 collected at Redlands, Cal., July 6, 1904, sample represented by formula 2-3-2-1, from 4 plants.

No. 7876 collected in same locality May 6, 1905, sample represented by formula 1-2-1, from 4 plants.

#### Chemical Analyses

|                            | Green. |       | Air Dry. |       |
|----------------------------|--------|-------|----------|-------|
|                            |        |       |          |       |
| Sample No.....             | 65.73  | 78.76 | 65.73    | 78.76 |
| Spines.....                | .66    | .21   | 2.14     | 1.47  |
| Water.....                 | 71.54  | 86.26 | 7.98     | 5.06  |
| Ash.....                   | 5.70   | 1.88  | 18.45    | 13.01 |
| Crude Protein. . . . .     | .61    | .35   | 1.97     | 2.41  |
| Crude Fat.....             | .32    | .23   | 1.03     | 1.60  |
| Nitrogen Free Extract..... | 18.26  | 9.48  | 59.07    | 65.48 |
| Crude Fiber.....           | 3.57   | 1.80  | 11.55    | 12.45 |
| Organic Matter.....        | 22.76  | 11.86 | 73.62    | 81.94 |

Nos. 7475 and 7476.

#### CACANAPA

##### OPUNTIA CACANAPA *n. sp.*

An erect, open branching shrub 4 to 6 feet high, with a scaly black trunk 4 to 6 in. in diameter; joints subcircular to obovate, 5 to 7 or 8 in. in greatest diameter, thin, light to glaucous green, brown and scurfy in age; areoles  $\frac{1}{2}$  to  $1\frac{1}{2}$  in. apart, subcircular to ovate, about  $\frac{1}{8}$ - $\frac{3}{16}$  in. in longest diameter, but increasing with age to  $\frac{1}{4}$  in. or more; spicules yellow, not conspicuous on sides of joint but often  $\frac{1}{4}$  in. or more long on edges; spines yellow, sometimes but not usually red at base, flattened, annular, usually not twisted, single, erect, 1 to 2 in. in length; flowers yellow to orange with seldom a tinge of red at base of petals and with white or slightly pinkish style and filaments and white or yellowish green stigma; fruits red throughout, small, obovate to subglobose, about 1 in. in diameter, with comparatively thick rind.

This species has heretofore been confused with *Opuntia lindheimeri*, to which it is related and with which it is always

associated. It is easily distinguished from the latter, however, by its more open branching habit, more woody texture and thinner, more nearly circular joints, single erect spines, smaller, more nearly globular fruit and later maturity. Cacanapa produces flowers and fruits a month to six weeks later than *Opuntia lindheimeri* growing beside it. (See Bull. 91 Bureau Animal Industry, U. S. D. A. for further notes upon this species.) The botanical type of this species is No. 8383 D. G. collected at Encinal, Texas, August 12, 1906.

No. 7475 collected at Encinal, Texas, January 10, 1905 sample represented by formula 3-1-1 from 3 plants.

No. 7476 collected from two of the above plants at same time and place, sample consisting of two sections from the old woody stem six inches above the ground.

#### Chemical Analyses

| Sample No...               | Green |       | Air Dry |       |
|----------------------------|-------|-------|---------|-------|
|                            | 7475  | 7476  | 7475    | 7476  |
| Spines.....                | .25   |       | 1.41    |       |
| Water.....                 | 83.05 | 80.98 | 3.92    | 6.78  |
| Ash.....                   | 4.66  | 4.08  | 26.40   | 20.00 |
| Crude Protein.....         | .88   | .71   | 4.99    | 3.46  |
| Crude Fat.....             | .35   | .37   | 2.00    | 1.83  |
| Nitrogen Free Extract..... | 9.16  | 9.49  | 51.94   | 45.53 |
| Crude Fiber.....           | 1.90  | 4.37  | 10.75   | 21.40 |
| Organic Matter.....        | 12.29 | 14.94 | 69.68   | 73.22 |

#### Analyses of the Ash

| Sample No. | Per Cent. Carbon | Per Cent. Sand | Per Cent. in Pure Ash.             |           |                |                |              |                |               |             |                                               |                                              |               |                                             |
|------------|------------------|----------------|------------------------------------|-----------|----------------|----------------|--------------|----------------|---------------|-------------|-----------------------------------------------|----------------------------------------------|---------------|---------------------------------------------|
|            |                  |                | Soluble Silica (SiO <sub>2</sub> ) | Iron (Fe) | Aluminium (Al) | Manganese (Mn) | Calcium (Ca) | Magnesium (Mg) | Potassium (K) | Sodium (Na) | Phosphoric Acid<br>radicle (PO <sub>4</sub> ) | Sulphuric Acid<br>radicle (SO <sub>4</sub> ) | Chlorine (Cl) | Carbonic Acid<br>radicle (CO <sub>2</sub> ) |
| 7476       | .11              | 1.74           | 1.23                               | .26       | .13            | .36            | 26.03        | 2.38           | 13.11         | 1.16        | .55                                           | 1.03                                         | 5.20          | 47.08                                       |



Nos. 6578, 6579, 7809 and 7812

**OPUNTIA INERMIS** *P. DC. Plant. Grass. t. 138. 1799.*

An erect ascending, loosely branched plant 2 to 4 feet high; joints narrowly obovate, in proportion of 3x9 in. which is a common size, deep blue green; leaves about  $\frac{1}{16} \times \frac{1}{8}$  in., subulate, cuspidate; areoles very variable, elongated to oval, about  $\frac{1}{8} \times \frac{1}{4}$  in.; wool dull tawny; spicules yellow, inconspicuous and entirely harmless upon young joints but becoming  $\frac{1}{4}$  in. long on older ones; spines almost absent, only an occasional yellow or brown one on edges of joints, not increasing on old trunks,  $\frac{1}{4}$  to 1 in. long, terete, flowers yellow or greenish-yellow with green style, filaments and stigma; fruit obovate to long pyriform, deep purple throughout, with prominent, yellow spicules 1-16 in. or more long.

Although a very prolific fruit bearer, this species is not a rapid grower in this climate. It is one of the common spineless forms of the cultivated plantations of this country and Europe.

The fruit and floral characters, as illustrated by DeCandole's figures<sup>1</sup>, correspond very well with our plant but the joints do not correspond so well. But the synonymy of this species seems reasonably straight, Weber<sup>2</sup>, Schumann<sup>3</sup>, Regel<sup>4</sup> and others referring undoubtedly to the same species. A typical figure may be found in *Gartenflora* 31: 132. 1882.

No. 6578 secured from The Albert S. White Park, Riverside, Cal., July 7, 1904, sample represented by formula 2-2-2, from one plant.

No. 6579 collected at the same time and place as No. 6578, sample consisting of 80 fruits from one plant.

No. 7809 collected from same plant as No. 6578 April 29, 1905, sample represented by formula 2-2-1.

No. 7812 collected at same time and place as No. 7809, sample consisting of 32 fruits from 2 plants.

1. *Plant. Grass* No. 138. 1799.

2. *Bols Dict. d'Hort.* 894. 1893-1899.

3. *Gesamtbeschreibung d. Kakt.* 718. 1848.

4. *Gartenflora* 31: 132. 1882.

## Chemical Analyses.

|                            | Green. |        |       |        | Air Dry. |        |       |        |
|----------------------------|--------|--------|-------|--------|----------|--------|-------|--------|
|                            |        |        |       |        |          |        |       |        |
| Sample No. ....            | 65.78  | 65.791 | 78.09 | 78.121 | 65.78    | 65.791 | 78.09 | 78.121 |
| Spines .....               | .....  | .....  | ..... | .....  | .....    | .....  | ..... | .....  |
| Water .....                | 88.11  | 91.56  | 86.54 | 87.11  | 9.32     | 7.35   | 6.29  | 5.57   |
| Ash .....                  | 4.34   | 1.58   | 2.94  | 1.49   | 33.08    | 17.30  | 20.45 | 10.90  |
| Crude Protein.....         | .55    | .57    | .58   | .50    | 4.16     | 6.24   | 4.05  | 3.68   |
| Crude Fat .....            | .12    | .35    | .16   | .32    | .93      | 3.88   | 1.10  | 2.34   |
| Nitrogen Free Extract..... | 5.37   | 4.32   | 8.77  | 8.31   | 41.01    | 47.43  | 61.06 | 60.90  |
| Crude Fiber.....           | 1.50   | 1.62   | 1.01  | 2.27   | 11.50    | 17.80  | 10.25 | 16.61  |
| Organic Matter.....        | 7.55   | 6.86   | 10.52 | 11.40  | 57.60    | 75.35  | 73.26 | 83.53  |

Nos. 6242, 7784, 8052a and 8022b D. G., and 3025 and 3067

E. O. W.

OPUNTIA PHAEACANTHA *Engelm. Mem. Am. Acad. (Plant. Fend.) 4: 52. 1849.*

Plants ascending to prostrate,  $1\frac{1}{2}$  to 3 feet high; joints obovate or in older, lower, prostrate ones semi-obovate,  $3\frac{1}{4}$  to  $5\times 5$  to 7 in., yellow to glaucous green; leaves about 3-32 in.  $\times$   $\frac{1}{4}$  in., subulate cuspidate; areoles circular to ovate-obovate,  $\frac{3}{4}$  to  $1\frac{1}{4}$  in. apart; wool dark tawny; spicules abundant, reddish brown, commonly  $\frac{1}{8}$  in. long on sides of joint but often  $\frac{1}{4}$  in. on edges; spines from light to dark red and becoming bleached to chalky with age but their bases nearly always darker than tips, 1 to 2 in. long, flattened and often slightly twisted 1 to 4 in number and always more numerous above, erect, divergent, or often somewhat recurved, very variable; flowers yellow with stigma yellowish to very light green and style and filaments greenish; fruit obovate,  $1\frac{1}{2} \times 2$  in., depressed at apex, with prominent areoles, about  $\frac{1}{4}$  in. apart, reddish-purple outwardly with pulp and rind greenish-yellow.

This species is exceedingly variable and it is very doubtful whether our knowledge of it is at all adequate. *O. phaeacantha brunnea* is represented in the foregoing list by by Nos. 8022a and 8022b and possibly by 3025. This variety has the habit of changing its aspects with growth very decidedly. In summer the season's growth is glaucous and

spines black but with age the color of the joints become yellowish-green and the spines reddish-brown, the contrast being most striking.

Of several specimens of our own collection before us only those from the exact locality of the two first numbers above have pulp or rind at all red and even here there is but little pulp, the fruit being not at all juicy. Joint characters agree very well with the type. But they also agree nearly as well with *O. camanchica* but the fruit of the latter is said to be red throughout, palatable and juicy. It is quite probable that the two numbers referred to above with red pulp are not normal. Insects do much damage to the fruits of all species in this locality and it may be that the dryness of the fruits is due here, as in other species which we have observed, to insect influences.

The type of *O. camanchica* does not differ from some of the forms of *phaeacantha* in the Engelmann Herbarium so far as the characters which are evident now are concerned. It is possible that they grade into each other. The description of the fruit, however, leads us to keep them separate for the present. *O. phaeacantha* has fruit with a greenish interior while *O. camanchica* is said to have fruit red throughout with pulp sweet and edible. It is possible that the two forms should be united but we cannot be certain about the matter until we have studied the species in the type locality of *O. camanchica*.

No. 6242 collected in Santa Rita Mountains, Arizona, April 30, 1904, sample represented by formula 2-2-3, from 3 plants.

No. 7784 collected in same locality April 19, 1905, and represented by formula 1-1-1-0 1, from 2 plants.

No. 8022a collected at El Paso, Texas, July 30, 1905, sample consisting of seed.

No. 8022b, same fruit as 8022a minus seed.

No. 3025 E. O. W. collected at Ancho, New Mexico, August 1904, sample consisting of joints Plants growing in cedar zone.

Plant low, prostrate to ascending, seldom over 18 inches high; joints obovate or, in case they are prostrate, roughly subcircular to cuneiform, bright, smooth, yellowish-green,

5 to 6 in. by 6 to 8 in.; areoles  $\frac{3}{4}$  to  $1\frac{1}{2}$  in. apart, circular to obovate, 3-16 in. longest diameter; spicules yellow, prominent, 3-16 in. long on last year's joints but increasing with age to  $\frac{1}{2}$  in.; spines red at base with opalescent brown tips but weathering to a chalky white, 2 to 4, mostly 3, 1 to  $1\frac{1}{2}$  in. long; flowers with inner petals yellow above, orange about middle and reddish at base on inner side, outer ones with greenish ribs, style and filaments white or greenish and stigma yellowish-green; fruits obovate, purple outside and greenish within.

These numbers are treated separately from the previous group on account of the constantly smaller joints. The plant grows upon the gentle slopes of the open grassy areas in upper foothills.

No. 7009 collected in the Santa Rita Mountains, Arizona, August 30, 1904, sample represented by formula 2-2-0-1 from 5 plants.

No. 7010 collected at same time and place as No. 7009, sample consisting of fruits from 8 plants.

No. 7759 collected in same locality April 17, 1905, sample represented by formula 1-1-1, from 3 plants.

#### Chemical Analyses

| Sample No.....             | Green. |                   |       | Air Dry. |                   |       |
|----------------------------|--------|-------------------|-------|----------|-------------------|-------|
|                            | 7009   | 7010 <sup>1</sup> | 7759  | 7709     | 7010 <sup>1</sup> | 7759  |
| Spines.....                | .29    | .....             | .34   | 2.50     | .....             | 1.99  |
| Water .....                | 88.88  | 84.37             | 83.98 | 4.54     | 5.20              | 6.84  |
| Ash .....                  | 2.33   | 1.23              | 2.02  | 19.90    | 7.43              | 11.78 |
| Crude Protein.....         | .69    | .76               | .73   | 5.91     | 4.60              | 4.25  |
| Crude Fat.....             | .20    | .96               | .88   | 1.70     | 5.80              | 2.20  |
| Nitrogen Free Extract..... | 6.45   | 8.40              | 10.98 | 55.10    | 61.02             | 64.12 |
| Crude Fiber.....           | 1.50   | 4.28              | 1.96  | 12.85    | 25.95             | 11.41 |
| Organic Matter.....        | 8.84   | 14.40             | 14.05 | 75.56    | 87.37             | 81.98 |

<sup>1</sup> Fruit.

No. 3069 E. O. W.

*OPUNTIA PHAEACANTHA* Engelm. *Mem. Am. Acad. Plant. Fend. 4: 52. 1849.*

A prostrate to ascending, spreading species, which dies at

base and strikes root distally, giving a central dead area and a vigorous marginal; one joints obovate, rather light green, in proportion of  $4 \times 6$  in., which is a common size; leaves subulate cuspidate, pointed, about 3-16 in. long; spicules yellow, prominent, in an unequal  $\frac{1}{2}$  in. long bunch from upper part of areole or occupying nearly the entire area of the lower ones, commonly  $\frac{1}{2}$  to 3-16 in. long; spines reddish-brown, weathering to a chalky white rather irregularly, some plants scarcely showing any brown while others retain it indefinitely, angularly flattened, largest ones 1 to 2 in. long and 1 to 4 or 5 in number with 1 to 3 additional shorter ones on lateral lower margins of areole, always sloping downward but often tightly recurved; flowers yellow with petals tipped with red externally and always appearing red when closed; fruits obovate to pyriform, very variable, about  $1 \times 2$  in., purple externally.

This differs from the other forms by its more slender, lighter colored spines and its smaller size throughout. It agrees in some respects with *O. setispina* Engelm. We believe it to be specifically distinct from the previous numbers recorded under *O. phaeacantha*.

Collected at Agricultural College, New Mexico, December 22, 1904, sample consisting of joints.

#### Chemical Analyses.

|                             | Green. | Ah Dry. |
|-----------------------------|--------|---------|
| Sample No.....              | 30.69  | 30.69   |
| Spines.....                 | 4.08   | 11.63   |
| Water.....                  | 67.40  | 6.50    |
| Ash.....                    | 6.02   | 17.16   |
| Crude Protein.....          | 1.08   | 3.07    |
| Crude Fat.....              | .64    | 1.83    |
| Nitrogen Free Extract ..... | 21.60  | 62.24   |
| Crude Fiber.....            | 3.26   | 9.30    |
| Organic Matter.....         | 26.58  | 76.84   |

Nos. 3013, 3100 and 3101 E. O. W.

OPUNTIA POLYCANTHA? Haw.

A low, prostrate to ascending plant seldom 12 in. high; joints obovate in proportion of  $2\frac{1}{2} \times 3\frac{1}{2}$  in., which is a common

size, bright green when young but becoming dark with age, more or less wrinkled; leaves small, subulate cuspidate, about  $\frac{1}{4}$  in. long; spicules yellow, short, with often a few long, rather stout, brownish ones on upper edge which almost appear to be between spines and spicules; spines white upon mature plants but somewhat brownish when young, soon fading to white but the tips often decidedly brown for some time, finally fading to a dark translucent bony consistence. On sides of joints there is usually one to two or three large central spines  $1\frac{1}{4}$  to  $1\frac{1}{2}$  in. long sloping downward slightly or erect-spreading, flattened, slightly or not at all twisted and marginal 2 to 6 short, tightly recurved more delicate ones, on the margins both forms more numerous; flowers yellow with usually greenish-red in all exposed portions of bud, filaments either green or red and stigma bright deep green; fruits oval to obovate, about  $\frac{3}{4} \times 1\frac{1}{4}$  in., dry.

Good specimens in the herbaria of both New Mexico Agricultural College and U. S. Department of Agriculture will serve to identify further the form which we have analyzed of this very variable species, the extremes of whose forms appear to be worthy of specific rank but whose intergrading forms make it a difficult to separate it into distinct species.

No. 3018 E. O. W. collected south of Tierra Amarilla, New Mexico, August 16, 1904, sample consisting of joints.

No. 3100 E. O. W. collected at Lakewood, New Mexico, August 3, 1905, sample consisting of joints including a few green fruits,

No. 3101 E. O. W. collected at same time and place but from smaller jointed plants.

#### Chemical Analyses

| Sample No. ....            | Green. |       |       | Air Dry. |       |       |
|----------------------------|--------|-------|-------|----------|-------|-------|
|                            | 30.18  | 31.00 | 31.01 | 30.18    | 31.00 | 31.01 |
| Spines .....               | .88    | 1.09  | 2.24  | 7.61     | 8.89  | 17 .  |
| Water.....                 | 89.54  | 88.24 | 88.82 | 9.73     | 4.65  | 6.68  |
| Ash.....                   | 1.78   | 3.75  | 2.90  | 15.35    | 30.39 | 23.23 |
| Crude Protein.....         | .60    | .43   | .49   | 5.15     | 3.50  | 3.94  |
| Crude Fat .....            | .21    | .21   | .15   | 1.78     | 1.70  | 1.16  |
| Nitrogen Free Extract..... | 6.56   | 5.94  | 6.77  | 56.66    | 48.14 | 53.04 |
| Crude Fiber.....           | 1.31   | 1.43  | 1.37  | 11.33    | 11.62 | 10.96 |
| Organic Matter.....        | 8.68   | 8.01  | 8.78  | 74.92    | 64.96 | 70.09 |

## Analyses of the Ash

| Sample No | Per cent. carbon | Per cent. sand | Per Cent. in Pure Ash              |           |               |                |              |                |               |             |                                               |                                              |               |                                             |
|-----------|------------------|----------------|------------------------------------|-----------|---------------|----------------|--------------|----------------|---------------|-------------|-----------------------------------------------|----------------------------------------------|---------------|---------------------------------------------|
|           |                  |                | Soluble Silica (SiO <sub>2</sub> ) | Iron (Fe) | Aluminum (Al) | Manganese (Mn) | Calcium (Ca) | Magnesium (Mg) | Potassium (K) | Sodium (Na) | Phosphoric Acid<br>radicle (PO <sub>4</sub> ) | Sulphuric Acid<br>radicle (SO <sub>4</sub> ) | Chlorine (Cl) | Carbonic Acid<br>radicle (CO <sub>2</sub> ) |
|           |                  |                |                                    |           |               |                |              |                |               |             |                                               |                                              |               |                                             |
| 3018      | .21              | .63            | .52                                | .20       | 0.00          | .32            | 24.01        | 5.81           | 14.15         | .12         | 1.19                                          | 2.97                                         | 6.18          | 42.06                                       |

No. 3016 E. O. W.

*OPUNTIA sp.*

This sample may represent an undescribed species. At all events we are unable to refer it to any species already described. We therefore prefer to leave it unnamed until we are able to secure more critical field notes upon it. It is fairly common at an altitude of 6000 to 7000 feet in the mountains of southwestern Colorado.

Collected at Flora Vista, New Mexico, August 9, 1904, sample consisting of joints.

## Chemical Analyses

|                            | Green | Air Dry |
|----------------------------|-------|---------|
| Sample No.....             | 3016  | 3016    |
| Spines.....                | 1.16  | 8.43    |
| Water.....                 | 87.37 | 8.10    |
| Ash.....                   | 3.05  | 22.18   |
| Crude Protein.....         | 1.37  | 9.96    |
| Crude Fat.....             | .24   | 1.75    |
| Nitrogen Free Extract..... | 6.27  | 45.61   |
| Crude Fiber.....           | 1.70  | 12.40   |
| Organic Matter.....        | 9.58  | 69.72   |



### Analyses of the Ash

| Sample No. | Per Cent. Carbon. | Per Cent. Sand. | Per Cent. in Pure Ash.             |           |               |                |              |                |               |             |                                            |                                           |               |                                          |       |
|------------|-------------------|-----------------|------------------------------------|-----------|---------------|----------------|--------------|----------------|---------------|-------------|--------------------------------------------|-------------------------------------------|---------------|------------------------------------------|-------|
|            |                   |                 | Soluble Silica (SiO <sub>2</sub> ) | Iron (Fe) | Aluminum (Al) | Manganese (Mn) | Calcium (Ca) | Magnesium (Mg) | Potassium (K) | Sodium (Na) | Phosphoric acid radicle (PO <sub>4</sub> ) | Sulphuric acid radicle (SO <sub>4</sub> ) | Chlorine (Cl) | Carbonic acid radicle (CO <sub>2</sub> ) |       |
| 30.16      | .27               | 3.67            | 1.82                               | .12       | .79           | .21            | 20.24        | 6.64           | 16.27         |             | .30                                        | 2.04                                      | 1.95          | 1.96                                     | 43.11 |

Nos. 3000 and 3066 E. O. W.

OPUNTIA MACROCENTRA *Engelm. and Bigel. Proc. Am. Acad. Arts and Sci.* 8: 292. '1856.

A suberect or spreading-ascending plant with commonly a purplish tinge or often distinctly purple throughout; joints subcircular but often ovate or obovate, about 6 or 7 in. in longest diameter; spicules reddish-brown but often yellow, prominent, unequal in a conical or lenticular bunch,  $\frac{1}{8}$  in. in length in upper portion of areole; spines long, prominent, erect, brown to black, fading distally to light brown or even chalky white with translucent, bonelike tip, usually single on sides of joints but two or three on edges above and entirely absent on lower portion of the joint, often 3 in. long, flattened and often slightly twisted; flowers yellow with some red in midribs and at bases of inner petals, consequently more or less red when old or closed, style purplish, filaments and stigma greenish-white; fruit obovate to pyriform, about  $1\frac{1}{4} \times 2\frac{1}{2}$  in., generally pitted at apex, purple without with greenish pulp and rind.

This is quite a characteristic and distinct species of western Texas and adjacent New and Old Mexico and extends as far west as the Santa Cruz Valley of Arizona. Its long, straight, mostly, dark brown to black spines and subcircular joints are its chief characteristics.

No. 3000 E. O. W. collected near Garfield, New Mexico,  
July 11, 1904, sample consisting of joints.

No. 3066 E. O. W. collected 3 miles east of Agricultural

College, New Mexico, December 22, 1904, sample consisting of joints.

### Chemical Analyses

| Sample No.            | Green. |       | Air Dry. |       |
|-----------------------|--------|-------|----------|-------|
|                       | 3000   | 3066  | 3000     | 3066  |
| Spines                |        | 1.46  |          | 6.16  |
| Water                 | 62.93  | 77.41 | 7.18     | 4.75  |
| Ash                   | 6.57   | 4.86  | 16.45    | 20.50 |
| Crude Protein         | 1.88   | 1.30  | 4.71     | 5.52  |
| Crude Fat             | .80    | .48   | 2.00     | 3.06  |
| Nitrogen Free Extract | 22.05  | 13.33 | 55.21    | 56.12 |
| Crude Fiber           | 5.77   | 2.62  | 14.45    | 11.05 |
| Organic Matter        | 30.50  | 17.73 | 76.37    | 74.75 |

### Analyses of the Ash

| Sample No. | Per Cent. Carbon. | Per Cent. Sand. | Per Cent. in Pure Ash.             |           |               |                |              |                |               |             |                                               |                                              |               |                                             |
|------------|-------------------|-----------------|------------------------------------|-----------|---------------|----------------|--------------|----------------|---------------|-------------|-----------------------------------------------|----------------------------------------------|---------------|---------------------------------------------|
|            |                   |                 | Soluble Silica (SiO <sub>2</sub> ) | Iron (Fe) | Aluminum (Al) | Manganese (Mn) | Calcium (Ca) | Magnesium (Mg) | Potassium (K) | Sodium (Na) | Phosphoric Acid<br>radicle (PO <sub>4</sub> ) | Sulphuric Acid<br>radicle (SO <sub>4</sub> ) | Chlorine (Cl) | Carbonic Acid<br>radicle (CO <sub>2</sub> ) |
| 3000       | .62               | 4.27            | 1.56                               | .53       | 0.00          | .56            | 24.75        | 8.25           | 8.33          | 1.57        | 2.14                                          | 1.16                                         | .95           | 44.80                                       |

Nos. 6543, 6544 and 7568.

*OPUNTIA MACRORHIZA* Engelm. *Boston Jour. Nat. Hist.* 5: 206. 1845.

A small, prostrate or ascending, usually tuberous rooted species of little economic promise; joints dark green, always more or less wrinkled, tuberculate, obovate, subcircular or even pointed at both ends, commonly  $3\frac{1}{2}$  x 5 in.; areoles obovate, about  $\frac{3}{4}$  in. apart; spicules very unequal, reddish-brown, in semicircle or often surrounding the entire areole or sometimes occupying it entirely,  $\frac{1}{8}$  in. or more long; spines red-

dish-brown, erect-spreading, 2 to 5, 1 to 1½ in. long, slightly flattened; flowers orange but petals red below on inner surface and commonly streaked with red above; fruit long, pyriform, depressed at apex or often flat when well developed, purple without and greenish or mottled within.

This is too small to be of much promise as stock food. Around San Antonio it is often difficult to find the tuberous roots where hogs run loose. In pastures where the animals run, the ground about the plants is invariably rooted up and the roots of the plants eaten off. Of course the joints strike root and grow again but usually no tubers are found upon them for several years. Our plant is without doubt Engelmann's species. A good illustration will be found in U. S. & Mex. Bound. Sur. 2: Pl. 69. 1859.

No. 6543 collected south of Hebronville, Texas, June 15, 1904, sample consisting of fruits from 6 plants.

No. 6544 collected at the same time and place as No. 6543, sample represented by formula 3-2-1-1, from 6 plants.

No. 7568 collected at San Antonio, Texas, February 23, 1905, sample represented by formula 1-2-3, from 5 plants.

#### Chemical Analyses.

| Sample No.....             | Green |       |       | Air Dry |       |       |
|----------------------------|-------|-------|-------|---------|-------|-------|
|                            | 6543  | 6544  | 7568  | 6543    | 6544  | 7568  |
| Spines .....               |       | .47   | .69   |         | 2.16  | 3.41  |
| Water .....                | 91.28 | 79.37 | 80.96 | 6.10    | 5.60  | 5.82  |
| Ash .....                  | 1.23  | 6.21  | 4.11  | 13.25   | 28.40 | 20.31 |
| Crude Protein.....         | .62   | 1.29  | 1.20  | 6.68    | 5.91  | 5.92  |
| Crude Fat.....             | .50   | .38   | .35   | 5.40    | 1.75  | 1.73  |
| Nitrogen Free Extract..... | 4.37  | 9.43  | 11.51 | 46.89   | 43.16 | 56.99 |
| Crude Fiber.....           | 2.00  | 3.32  | 1.87  | 21.68   | 15.18 | 9.23  |
| Organic Matter.....        | 7.51  | 14.42 | 14.93 | 80.65   | 66.00 | 73.87 |

1 Fruit.

No. 7639

## NOPAL LASARON (?)

OPUNTIA STENOPETALA Engelm. U. S. & Mex. Bound.  
*Sur. 2: Cactaceae 46. Pl. 66. 1859.*

A prostrate, spreading, small plant, seldom over 18 inches high: joints subcircular, 4 to 6 in. in diameter, dark green, glaucous, with a tinge of purple around areoles and edges of joints; leaves scarlet, 1-16 in. wide by  $\frac{1}{4}$  in. long, subulate, with prominent white wool at base; areoles circular below and oval above, about 3-16 in. in greatest diameter, and 1 to  $1\frac{1}{2}$  in. apart; wool tawny but black where exposed; spicules red but soon becoming black where exposed, about  $\frac{1}{8}$  in. long; spines at first red but becoming decidedly chalky and finally black, with translucent tips, 1 to 4, usually 3 or 4, annular, recurved or simply spreading, very variable in length but commonly 1 to 2 in.; flowers said to be dioecious, orange-red with white filaments and yellow, 8 to 9 parted stigma; fruit subglobose, with truncate to depressed apex, and conspicuous areoles, wine red exteriorly with streaked rind and greenish pulp slightly mottled with red, very acid.

Weber<sup>1</sup>, whom Schumann<sup>2</sup> follows, considered *O. stenopetala* a synonym of *O. glaucescens* Salm. but Berger<sup>3</sup> has recently shown that this, as well as *O. grandis* Pfeiff., is a different thing entirely. Both the specific name and the descriptions would indicate that this is true. Our plants match Engelman's type perfectly. This is too small to be of value as stock food but it is one of the most valuable ornamentals and is hardy in southern California, although it does not appear to fruit well. The common name used above was applied to this plant by a peon at Ypiña, San Luis Potosi, Mexico.

Collected at Alonzo, Mexico, March 14, 1905, sample represented by formula 1-1-1, from 2 plants.

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1. Bois, Dict. d'Hort. 293. 1893-1899.

2. Gesamtbeschreib. d. Kakt. 742. 1899.

Engler's Bot. Jahrbuchern 36: 447. 1905.

## Chemical Analyses

No. 7639.

|                             | Green. | Air Dry |
|-----------------------------|--------|---------|
| Spines. ....                | .02    | .14     |
| Water. ....                 | 86.76  | 6.40    |
| Ash. ....                   | 3.98   | 20.75   |
| Crude Protein. ....         | 1.17   | 8.28    |
| Crude Fat. ....             | .28    | 1.65    |
| Nitrogen Free Extract. .... | 7.70   | 54.39   |
| Crude Fiber. ....           | 1.31   | 8.53    |
| Organic Matter. ....        | 10.81  | 73.86   |

Nos. 6580 and 7813.

OPUNTIA MONACANTHA<sup>1</sup> *Haw. Suppl. Plant. Suc. 81. 1819.*

An ascending or erect, sparingly branched and very prolific fruited species; joints obovate, commonly contracted below into a long, stipitate base, in proportion of 4 x 8 and 5 x 10 in., which are common sizes, bright green, smooth, somewhat tuberculate; areoles oval, obovate, about 3-16 x  $\frac{1}{2}$  in. but very variable and becoming very much elongated with protruding, tawny wool on old joints; spicules yellow, inconspicuous, and not increasing upon old stems; spines normally one and erect, gray, with conspicuous horn-like tip but increasing irregularly to as high as 10 upon old stems,  $\frac{1}{2}$  to 1 in. long but upon old stems often 3 in. long; flowers yellow with tips of outer segments red, style and filaments white or greenish and stigma yellowish-white; fruit proliferous, green, with a blush of red on outside, about 1 $\frac{1}{4}$  x 3 in. when fully grown, remaining upon trees for 4 or 5 years and developing continually.

This is one of the few flat-jointed prickly pears with proliferous fruits. These remain attached to the plant for 4 or 5 years, putting forth new ones from year to year until there is a string of them sometimes 6 or 8 inches long, containing 8 or 10 individual fruits. Not only do the fruits remain on

1. The variegated variety is commonly advertised in catalogues under the name. *Opuntia monacantha variegata*. It differs in no way from the species except in the unequal distribution of the green coloring matter in the joints.

the shrub but they continue to grow as long as they are so attached, the proximal always being larger than the distal ones. Our plant is evidently the same as that figured by Maiden in Agric. Gaz. New South Wales 9: opp. p. 1001. 1898. The species does not appear to grow so large in this country as here figured and the fruit with us is more prolific than this figure shows them to be. It is also figured by DeCandole Pl. Grass. Pl. 138. 1799. Professor Maiden reports it to be a bad weed in portions of Australia.

No. 6580 secured from The Albert S. White Park, Riverside, California, July 7, 1904, sample consisting of 20 fruits from one plant, represented by formula 12-5-2-1.

No. 7813 secured from the same plant April 29, 1905, sample consisting of 24 fruits 1 to 3 years old, the older ones predominating.

#### Chemical Analyses

|                            | Green. |       | Air Dry. |       |
|----------------------------|--------|-------|----------|-------|
|                            | 65801  | 78131 | 65801    | 78131 |
| Sample No.....             |        |       |          |       |
| Spines.....                |        |       |          |       |
| Water.....                 | 91.03  | 90.03 | 6.45     | 5.41  |
| Ash.....                   | 1.41   | 1.29  | 14.70    | 12.27 |
| Crude Protein.....         | .31    | .35   | 3.18     | 3.39  |
| Crude Fat.....             | .16    | .32   | 1.65     | 3.00  |
| Nitrogen Free Extract..... | 5.95   | 6.98  | 62.14    | 66.10 |
| Crude Fiber.....           | 1.14   | 1.03  | 11.88    | 9.83  |
| Organic Matter.....        | 7.56   | 8.48  | 78.86    | 82.32 |

1. Fruit.

Nos. 6691 and 7889.

#### PRICKLY PEAR. NOPAL.

*OPUNTIA CHLOROTICA* Engelm. and Bigel. *Pacif. Ry Rep.* 4: 38. Pl. 6, f. 1-3. 1856.

A tall, erect, woody, formidably protected prickly pear 4 to 6 or 7 feet high, with a well marked trunk; joints normally subcircular, 5 x 5½ in. to 6 x 7 in., glaucous to yellowish-green; areoles obovate to subcircular, prominent and numerous, ½

to  $\frac{1}{4}$  in. apart on sides of joints but often occupying entire margin, its tissues continuing to develop indefinitely upon old trunks, giving rise to a conical or cylindrical structure often  $\frac{1}{2}$  in. long covering, in many cases, the entire trunk, from the annual growth of which wool and spicules continue to develop abundantly but only rarely new spines; spicules yellow, very unequal, often  $\frac{1}{4}$  in. long, surrounding upper portion of areoles in young joints but scattered through it in older ones; spines yellow, 1 to 5, with 1 to 6 smaller, more delicate ones below, increasing but slightly on old joints but becoming more tightly recurved; flowers yellow with filaments and style white and 7-parted stigma greenish-white; fruit subglobose to obovate or even pyriform, purple without and greenish yellow within.

This is a very distinct and, in some respects, peculiar species. Its perfectly erect habit with well developed trunk, densely papillate stems and old joints are very characteristic. The proliferation of the tissues of the areole into conical or calumnar structures is not at all common but is very noticeable and characteristic in a few species of *Opuntia*, more especially in this and *Opuntia rufida*.

No. 6691 collected at Hackberry, Arizona, July 25, 1904, sample represented by formula 1-1-1-1, from 4 plants.

No. 7889 collected in same locality May 9, 1905, sample represented by formula 1-1- $\frac{1}{2}$ , from 3 plants.

#### Chemical Analyses

| Sample No.....             | Green |       | Air Dry |       |
|----------------------------|-------|-------|---------|-------|
|                            | 6691  | 7889  | 6691    | 7889  |
| Spines.....                | .80   | 1.75  | 3.01    | 7.77  |
| Water.....                 | 74.99 | 78.50 | 6.03    | 5.45  |
| Ash.....                   | 5.00  | 4.90  | 18.80   | 21.88 |
| Crude Protein.....         | .95   | .95   | 3.56    | 4.16  |
| Crude Fat.....             | .49   | .44   | 1.85    | 1.95  |
| Nitrogen Free Extract..... | 13.10 | 12.46 | 49.21   | 54.78 |
| Crude Fiber.....           | 5.47  | 2.75  | 20.85   | 12.10 |
| Organic Matter.....        | 20.31 | 16.60 | 75.17   | 72.97 |

Nos. 6241 and 7782.

OPUNTIA CHLOROTICA SANTA RITA *n. var.*

An erect, open branching prickly pear of woody texture, with a distinct trunk, 4 to 6 in. in diameter; joints mostly subcircular but sometimes ovate and pointed (No. 7783 D. G.) or obovate (No. 8156 D. G.), 5 to 7 in. in diameter, glaucous or in spring purplish around areoles and edges of joints especially; leaves about 1-16x $\frac{3}{4}$  in., subulate, early deciduous from the young purplish joints; areoles  $\frac{3}{4}$  to  $\frac{1}{2}$  in. apart, obovate to subcircular,  $\frac{1}{2}$  in. or more in longest diameter on one and two-year-old joints but increasing in size and prominence with age giving rise to columnar structures  $\frac{1}{2}$  to  $\frac{1}{4}$  in. long upon old trunks; wool tawny but brown outwardly, giving a brown appearance to areole; spicules varying from light yellow to brown and always dirty brown with age; spines nearly absent in these numbers, sometimes 1 to 3 on edges of joints only,  $\frac{3}{4}$  to 1 $\frac{1}{2}$  in. long, yellow to reddish-brown; flowers yellow with white filaments and style and white or yellowish, 7 parted stigma; fruit oval, depressed at apex, with very rough flower scar formidably protected with prominent spicules, purplish outwardly and greenish within, pleasantly acid.

We have not seen this form of the species in the northern highlands of the Territory where the typical form grows abundantly but in the southern mountains of Arizona this is the most common form. All gradations of spine characters may be found between this and the typical, very spiny *Opuntia chlorotica*. One very conspicuous character is the proliferation of tissue in the areoles upon old stems of this and the other form, giving a prominent papillum or small columnar projection  $\frac{1}{2}$  to  $\frac{1}{4}$  in. long covered with wool and formidablespicules. When the fruit ripens it falls to the ground and remains in good condition for a long time, not being molested by birds or animals. The pulp is comparatively small in amount and the rind thin, approaching the dry fruited forms to some extent in this respect. The botanical type of this variety is No. 8157 D. G. collected in Celero mountains, Arizona, October 8, 1905.

No. 6241 collected upon steep, rocky canyon sides in Santa



Rita Mountains, Arizona, April 30, 1904, sample represented by formula 2-3-2, from one plant.

No. 7782 collected from same locality April 19, 1905, sample represented by formula 1-1-1-1, from 4 plants.

### Chemical Analyses

|                            | Green. |       | Air Dry. |       |
|----------------------------|--------|-------|----------|-------|
|                            | 6241   | 7782  | 6241     | 7782  |
| Sample No .....            |        |       |          |       |
| Spines .....               |        |       |          |       |
| Water .....                | 77.87  | 79.47 | 5.63     | 5.77  |
| Ash .....                  | 5.89   | 3.73  | 25.10    | 17.10 |
| Crude Protein.....         | .95    | .85   | 4.05     | 3.89  |
| Crude Fat .....            | .49    | .43   | 2.08     | 1.98  |
| Nitrogen Free Extract..... | 11.55  | 12.15 | 49.27    | 55.80 |
| Crude Fiber.....           | 3.25   | 3.37  | 13.87    | 15.46 |
| Organic Matter.....        | 16.24  | 16.80 | 69.27    | 77.13 |

### Analyses of the Ash

| Sample No. | Per Cent. Carbon. | Per Cent. Sand. | Per Cent. in Pure Ash.             |           |               |                |              |                |               |             |                                            |                                           |               |                                          |
|------------|-------------------|-----------------|------------------------------------|-----------|---------------|----------------|--------------|----------------|---------------|-------------|--------------------------------------------|-------------------------------------------|---------------|------------------------------------------|
|            |                   |                 | Soluble Silica (SiO <sub>2</sub> ) | Iron (Fe) | Aluminum (Al) | Manganese (Mn) | Calcium (Ca) | Magnesium (Mg) | Potassium (K) | Sodium (Na) | Phosphoric acid radicle (PO <sub>4</sub> ) | Sulphuric acid radicle (PO <sub>4</sub> ) | Chlorine (Cl) | Carbonic acid radicle (CO <sub>2</sub> ) |
| 77.82      | .39               | .67             | .79                                | .10       | .27           | 1.36           | 33.23        | 2.78           | 3.12          | .15         | 1.07                                       | .67                                       | .58           | 53.68                                    |

No. 7591.

### NOPAL CARDON

OPUNTIA STREPTACANTHA *Cactarum Gen. Nov. 62.*  
(Paris) 1839.

A tall, stout, widely branching tree 10 to 15 or more feet high, with a black, scaly trunk 10 to 18 in. in diameter; joints ovate to obovate, in proportion of 10 to 12 in., which is a common size for last year's growth, 1 to 1½ in. thick, dark dull

green, flaking off the third or fourth year and finally changing into a black scaly trunk; areoles oval,  $\frac{1}{8}$  to  $\frac{1}{4}$  in. in longest diameter, black; spicules bright reddish-brown, seldom protruding to surface of joint; spines recurved in all directions, often tightly against the surface of the joint, upper ones more erect than the lower, 3 to 7, with often an additional 2 or 3 very delicate ones below, increasing in number to 9 or 10 from upper part of areole, at first opalescent, changing to white, which soon becomes mottled and finally dirty gray, flattened, twisted and usually grooved below; flowers yellow, varying to orange with tips of outer sepals red, outer filaments greenish yellow and inner tinged with red, style tinged with red near apex and stigma, 8 to 12 parted, light glossy green; fruit oval to subglobose, deep dull red with pulp darker than rind and easily separable from it.

This is one of the most distinct and characteristic of the Mexican pears. The dull, dark green, thick joints with mottled gray, recurved spines enable one to recognize it easily. The only other form with which it can be confused is nopal arton, which is a larger plant with larger, darker fruits and spines on the whole more erect. The variety which is here described is red fruited but there occurs a form with a yellowish-white fruits, known as nopal cardon blanco. The latter is rather rare in nature but is common in orchards. The common name cardon is uniformly referred to this plant throughout the region where it grows. It is one of the species whose popular name appears to be stable.

Collected at Aguas Calientes, Mexico, March 6, 1905, sample represented by formula 1-1-0-1, from 3 plants.

#### Chemical Analyses

No. 7591.

|                             | Green. | Air Dry. |
|-----------------------------|--------|----------|
| Spines .....                | .49    | 2.90     |
| Water .....                 | 83.90  | 3.75     |
| Ash .....                   | 3.32   | 19.85    |
| Crude Protein .....         | .51    | 3.07     |
| Crude Fat .....             | .32    | 1.90     |
| Nitrogen Free Extract ..... | 8.91   | 58.22    |
| Crude Fiber .....           | 3.04   | 18.20    |
| Organic Matter .....        | 12.78  | 76.40    |

## Analyses of the Ash

| Sample No. | Per Cent. Carbon. | Per Cent. Sand. | Per Cent. in Pure Ash.             |           |               |                |              |                |               |             |                                               |                                              |               |                                             |
|------------|-------------------|-----------------|------------------------------------|-----------|---------------|----------------|--------------|----------------|---------------|-------------|-----------------------------------------------|----------------------------------------------|---------------|---------------------------------------------|
|            |                   |                 | Soluble Silica (SiO <sub>2</sub> ) | Iron (Fe) | Aluminum (Al) | Manganese (Mn) | Calcium (Ca) | Magnesium (Mg) | Potassium (K) | Sodium (Na) | Phosphoric Acid<br>radicle (PO <sub>4</sub> ) | Sulphuric Acid<br>radicle (SO <sub>4</sub> ) | Chlorine (Cl) | Carbonic Acid<br>radicle (CO <sub>2</sub> ) |
| 7591       | .06               | .21             | 1.14                               | .20       | .19           | .04            | 30.10        | 2.70           | 10.10         | .58         | .29                                           | .41                                          | .63           | 50.25                                       |

No. 7635.

## NOPAL JARILLO

OPUNTIA *ap.*

Plant tall, erect, open branching, with a distinct black, scally trunk 10 to 12 in. in diameter; joints obovate in proportion of 7 x 12 in., which is a common size, dark green, slightly tuberculate for one or two years; areoles subcircular to obovate, about  $\frac{1}{4}$  in. apart; spicules seldom visible on upper part of joint, but there is usually a prominent, small reddish-brown bunch of unequal,  $\frac{1}{8}$  in. long ones in the lower, less spiny areoles; spines translucent, soon turning to white, with translucent tips and changing the second or third year to a grayish-brown, horn-like appearance, persisting to a remarkable degree upon all trunks 10 in. or more in diameter and continuing to increase in number and enlarge the areole to often  $\frac{1}{2}$  in. in diameter, the central and longest one erect, and the others spreading around it, the longest one often  $1\frac{1}{2}$  in. long the others varying as low as  $\frac{1}{2}$  in. with usually 2 or 3 delicate, easily separable ones besides, 4 to 8 on sides of joints with often 10 on edges, and increasing on old trunks to as high as 30, angular, flattened, twisted; flowers not seen; fruits obovate, somewhat tubercular, red, with pulp turning red before the rind and epidermis.

This is one of the most formidably protected of all of the prickly pears. The spines are very stout and brittle. The common name does not appear to be very well established.

Collected at San Luis Potosi, Mexico, March 13, 1905, sample represented by formula 1-1-1, from 3 plants.

## Chemical Analyses

No. 7635.

|                             | Green. | Air Dry. |
|-----------------------------|--------|----------|
| Spines .....                | .51    | 6.25     |
| Water .....                 | 92.35  | 5.60     |
| Ash .....                   | 1.79   | 22.05    |
| Crude Protein .....         | .82    | 10.07    |
| Crude Fat .....             | .16    | 2.15     |
| Nitrogen Free Extract ..... | 3.95   | 48.69    |
| Crude Fiber .....           | .93    | 11.44    |
| Organic Matter .....        | 5.86   | 72.35    |

No. 7715.

*OPUNTIA sp.*

A tall, open branching tree, with a black, scaly trunk 10 to 15 in. diameter, 15 feet or more high, and very woody; joints subcircular to obovate, 6 x 8 or 9 in., thin, slightly tuberculate, dark green, smooth and shiny, turning dark but very variable; areoles oval, 3-16 in. or more in greatest diameter,  $1\frac{1}{4}$  to  $1\frac{3}{8}$  in. apart; wool tawny; spicules yellow, very variable, often rather brown, unequal in length but commonly about  $\frac{3}{8}$  in. long; spines brown, turning to white at tips, leaving the bases brownish translucent but in second or third year they become dirty black, suberect, spreading with the lower recurved and central largest flattened and often twisted, 3 to 8 in number and increasing in both number and length for 2 or 3 years; flowers yellow, often streaked with red and always red without,  $1\frac{1}{2}$  in. across and about 1 in. long with filament light chocolate, and 6 to 9-parted light green stigma; fruits obovate or pyriform, covered with circular areoles well armed with long yellow spicules, rind thin and very deep red pulp.

The species is easily recognized by its dark, glossy green joints which turn very dark after maturity, its peculiar streaked flowers and its chocolate colored stamens.

Collected at Guadalajara, Mexico, April 6, 1905, sample represented by formula 1-1-1, from 3 plants.

## Chemical Analyses

No. 7715

|                             | Green | Air Dry |
|-----------------------------|-------|---------|
| Spines .....                | .27   | 2.11    |
| Water .....                 | 88.01 | 5.40    |
| Ash .....                   | 1.91  | 15.10   |
| Crude Protein .....         | .57   | 4.47    |
| Crude Fat .....             | .52   | 4.08    |
| Nitrogen Free Extract ..... | 6.23  | 49.07   |
| Crude Fiber .....           | 2.77  | 21.88   |
| Organic Matter .....        | 10.08 | 79.50   |

Nos. 6529, 6530, 6531 and 7590

## NOPAL TAPON

OPUNTIA ROBUSTA Wendl. Cat. Herrenh. (1835)<sup>1</sup>

Plant body very variable in size and habit, commonly erect 5 to 7 feet high but sometimes ascending and often erect and arborescent, 12 or 15 feet high when planted in favorable situations such as irrigating ditch banks; joints subcircular, very large and fleshy, often 18 to 24 in. in diameter and  $1\frac{1}{2}$  to 2 in. thick, glaucous, with abundant bloom when young but becoming scaly with age and producing a black, scaly trunk; areoles very large and conspicuous, subcircular 3-16 to 3-8 in in diameter and  $1\frac{1}{4}$  to 3 in. apart on sides of joints, dark brown to black; spicules yellow, forming a crescentic bunch on upper side of areole but often forming a complete ring surrounding it, commonly 1-16 to  $\frac{1}{2}$  in. long but often  $\frac{1}{2}$  or even 1 in. long on edges of joints; spines 2 to 6 in young joints, usually 3 to 5, but increasing to 7 or 8 on two-year-old joints, deep yellow to almost orange at base and fading outward to translucent bone-like tips and soon weathering white, stout, flattened, not annulate, slightly twisted; flowers large, 2 in. wide in full bloom, yellow with blush of red in portions exposed in the bud, with filaments and style white or greenish and stigma deep bright green, 8 to 9 parted; fruit subglobose, deep blood red throughout, usually more or less tuberculate, which largely disappears toward maturity.

This is a very characteristic and easily recognized species,

<sup>1</sup> Citation taken from Schumann's Gesamtbeschreib. d. Kakt. 741. 1898.

the common name of which is constant throughout the plateau region where it grows. It is always easily recognized by its very large, nearly circular, thick, glaucous joints.

No. 6529 collected at Alonzo, Mexico, June 10, 1904, sample consisting of 26 fruits from 9 plants. These were under mature but the pulp was red and rind just beginning to turn.

No 6530 collected at same time and place as No. 6529, sample represented by formula 2-2-1, from 5 plants.

No. 6531 collected at San Luis Potosi, Mexico, June 11, 1904, sample consisting of 11 fruits from 5 plants. In this sample the fruits were better matured, the entire rind being purplish red.

No. 7590 collected at Aguas Calientes, Mexico, March 6, 1905, sample represented by formula 1-0-1-0-1, from 3 plants.

#### Chemical Analyses

|                       | Green. |       |       |       | Air Dry. |       |       |       |
|-----------------------|--------|-------|-------|-------|----------|-------|-------|-------|
| Sample No.....        | 65291  | 6530  | 65311 | 75.90 | 65291    | 6530  | 65311 | 7590  |
| Spines .....          |        | .71   |       | .25   |          | 6.43  |       | 2.33  |
| Water .....           | 88.59  | 89.62 | 96.81 | 89.62 | 5.41     | 5.68  | 6.38  | 4.55  |
| Ash .....             | 1.29   | 2.95  | .26   | 1.93  | 10.70    | 26.81 | 7.65  | 17.79 |
| Crude Protein.....    | 1.06   | .63   | .23   | .46   | 8.76     | 5.70  | 6.79  | 4.27  |
| Crude Fat.....        | 1.13   | .23   | .23   | .18   | 9.38     | 2.13  | 6.76  | 1.64  |
| Nitrogen Free Extract | 3.84   | 4.81  | 1.80  | 5.98  | 31.80    | 43.70 | 52.72 | 54.95 |
| Crude Fiber.....      | 4.09   | 1.76  | .67   | 1.83  | 33.95    | 15.98 | 19.70 | 16.89 |
| Organic Matter.....   | 10.12  | 7.43  | 2.93  | 8.45  | 83.89    | 67.51 | 85.97 | 77.66 |

1. Fruit.

No. 7633.

#### NOPAL SAPON LISO.

#### OPUNTIA ROBUSTA WENDL.

As the Spanish popular name indicates, this is probably nothing more than a spineless form of the wild nopal tapon. It is very commonly cultivated throughout the highland region of Mexico. It appears to differ in no essential respect from the wild form except in the absence of spines. The spicules

are not as formidable on the joints as in the spined variety but are about the same on the fruits. We believe that we have seen this variety in nature but there is always more or less difficulty in distinguishing between native and escaped plants in Mexico.

Collected at San Luis Potosi, Mexico, March 13, 1905, sample represented by formula 1-1-1, from 3 plants.

### Chemical Analyses

No. 7633.

|                             | Green. | Air Dry. |
|-----------------------------|--------|----------|
| Spines. ....                |        |          |
| Water. ....                 | 90.25  | 5.53     |
| Ash. ....                   | 1.43   | 13.33    |
| Crude Protein. ....         | .88    | 3.72     |
| Crude Fat. ....             | .20    | 1.90     |
| Nitrogen Free Extract. .... | 6.95   | 67.40    |
| Crude Fiber. ....           | .79    | 7.63     |
| Organic Matter. ....        | 8.32   | 80.64    |

Nos. 6562, 6575, 7810 and 7841.

### MISSION PEAR, NOPAL DE CASTILLA <sup>1</sup>

#### OPUNTIA *sp.*

A tall, erect, prolific, cultivated plant, 10 to 15 feet high, with a trunk often 12 in. in diameter; joints obovate or often elliptical, smooth, bright or glaucous green, in proportion of 9 x 18 in. for one-year-old joints; areoles  $1\frac{1}{4}$  to 2 in. apart, oval to circular,  $\frac{1}{4}$  to  $\frac{1}{2}$  in. long, increasing in size and elongating transversely with age to 1 in. wide on old trunks; spicules yellow, inconspicuous and seldom long enough to seriously annoy one in handling the joints; spines white with translucent tips, turning to a dirty mottled gray with age, erect, divergent,  $\frac{1}{4}$  to  $1\frac{1}{4}$  in. long, flattened, occasionally twisted, 2 to 6 or 7, mostly 3 or 4, but increasing with age to twice that

1. This name is very commonly used among our Spanish population and in a much more restricted sense than in Mexico, where it is applied to a greater variety of species than with us. We do not interpret it to have any reference to the origin of the variety but simply indicates that it is of good quality. The name is used in much the same sense as some of our trade names.

number; flowers orange with bases of petals, filaments and style reddish, and bright, dark green, 8 or 9-parted stigma; fruit subglobose, elliptical or obovate, about 2 x 2½ in., greenish-yellow throughout.

This is the common cultivated, greenish-yellow fruited, spiny pear of our southwestern states. In California it is known as "Mission pear" on account of its appearance about the old missions to which it was first introduced. It is what is commonly referred to in this country as *O. tuna* Mill. but as recently pointed out by Berger<sup>1</sup>, Maiden<sup>2</sup>, and others, we cannot tell what *O. tuna* is and can see no immediate prospects of determining. Different authors have referred to it species of very widely differing characteristics. Some forms of this species are very nearly as spineless as what passes for *O. ficus-indica* in this country. (See the next number)..

No. 6562 secured from The Albert S. White park, Riverside, California, June 29, 1904, sample consisting of 17 fruits from 5 plants.

No. 6575 collected from same plants as No. 6562 July 7, 1904, sample represented by formula 2-2-1-1.

□ No. 7810 collected from same plants as above May 1, 1905, sample represented by formula 2-1-½.

No. 7841 collected from same plants as above May 2, 1905, sample consisting of 9 fruits from 4 plants.

1. Eng. Bot. Jahrbuch. 36: 456. 1905.

2. Agr. Gazette, New South Wales, 9: 997. 1898.

#### Chemical Analyses.

| Sample No.....        | Green. |       |       |       | Air Dry. |       |       |       |
|-----------------------|--------|-------|-------|-------|----------|-------|-------|-------|
|                       | 65621  | 6575  | 78.10 | 78411 | 65621    | 6575  | 7810  | 78411 |
| Spines .....          |        | .32   | .04   |       |          | 3.33  | .33   |       |
| Water.....            | 89.09  | 91.07 | 89.41 | 85.41 | 6.20     | 7.33  | 6.63  | 3.97  |
| Ash.....              | .91    | 2.00  | 1.60  | .77   | 7.80     | 20.80 | 14.05 | 5.07  |
| Crude Protein .....   | .48    | .32   | .35   | .46   | 4.16     | 3.29  | 3.07  | 3.06  |
| Crude Fat.....        | .33    | .12   | .23   | .33   | 2.85     | 1.20  | 2.00  | 2.20  |
| Nitrogen Free Extract | 7.31   | 4.95  | 7.21  | 10.03 | 62.84    | 51.43 | 63.48 | 72.58 |
| Crude Fiber.....      | 1.88   | 1.54  | 1.20  | 3.00  | 16.15    | 15.95 | 10.57 | 13.12 |
| Organic Matter.....   | 10.00  | 6.93  | 8.99  | 13.82 | 86.00    | 71.87 | 79.12 | 90.96 |

1. Fruit.



Nos. 7519 and 7577.

**NOPAL DE CASTILLA***OPUNTIA sp.*

We consider this to be the same as the Mission pear of southern California. It is cultivated in several situations in and about Laredo, Texas, and apparently has two forms, one somewhat spiny, resembling very closely the mission pear and the other nearly spineless. No. 7519 was from the spiny form; No. 7577 is nearly spineless. We have not seen the fruit of either one of these forms, consequently prefer to keep them separate from the previous numbers.

No. 7519, collected at Laredo, Texas, January 19, 1905, sample represented by formula 0-1-0-1-1, from 3 plants. All of the plants have been grown from a single cutting.

No. 7577 collected at Laredo, Texas, February 27, 1905, sample represented by formula 1-1-1, from 3 plants. These plants are supposed to have been introduced from Mexico.

**Chemical Analyses**

| Sample No.....             | Green. |       | Air Dry. |       |
|----------------------------|--------|-------|----------|-------|
|                            | 7519   | 7577  | 7519     | 7577  |
| Spines .....               | .36    | ..... | 1.82     | ..... |
| Water .....                | 81.16  | 92.25 | 5.18     | 8.12  |
| Ash .....                  | 4.29   | 1.75  | 21.65    | 20.80 |
| Crude Protein.....         | 1.32   | .63   | 6.68     | 7.53  |
| Crude Fat.....             | .28    | .16   | 1.40     | 1.85  |
| Nitrogen Free Extract..... | 8.88   | 4.62  | 44.56    | 47.60 |
| Crude Fiber.....           | 4.07   | 1.19  | 20.53    | 14.10 |
| Organic Matter.....        | 14.55  | 6.00  | 73.17    | 71.08 |

No. 7733.

**NOPAL CHAVENO***OPUNTIA sp.*

A tall, open branching tree 10 to 12 feet high, with a black, scaly trunk, 8 to 10 in. in diameter; joints obovate in proportion of 9 x 12 in., which is a common size, yellowish-green,

indistinctly short hairy or only pappilate; areoles circular below to broadly obovate above, about 3 16 in. in longest diameter but increasing in size with age,  $\frac{3}{4}$  to  $1\frac{1}{4}$  in. apart; wool tawny-brown, black where exposed; spicules lemon yellow, very variable in length, at times scarcely reaching surface of joint and at others  $\frac{3}{8}$  in. long; spines erect, divergent, 4 to 8 on sides of last year's joints but increasing in number for 8 or 10 years,  $\frac{1}{4}$  to  $\frac{3}{4}$  in. long, flattened and twisted on older joints; flowers yellow to light orange, with greenish filaments, reddish style and bright, light green stigma; fruit obovate, red, with a deeper red pulp, formidably protected by long, yellow spicules and when young by hair-like, fugacious spines  $\frac{1}{2}$  in. long, which drop off at maturity from areoles  $\frac{3}{8}$  to  $\frac{1}{2}$  in. apart.

In the Chaveño group the Mexicans recognize several varieties. We consider them to be one botanical species separated by minor but quite constant differences. They will receive further treatment in a future publication.

Collected at Aguas Calientes, Mexico, April 10, 1905, sample represented by formula 2-1-1, from 3 plants.

#### Chemical Analyses.

No. 7733.

|                             | Green. | Air Dry. |
|-----------------------------|--------|----------|
| Spines .....                | .27    | 2.06     |
| Water .....                 | 88.01  | 6.48     |
| Ash .....                   | 2.61   | 20.34    |
| Crude Protein .....         | .47    | 3.66     |
| Crude Fat. ....             | .23    | 1.87     |
| Nitrogen Free Extract ..... | 6.81   | 52.57    |
| Crude Fiber .....           | 1.87   | 15.08    |
| Organic Matter .....        | 9.39   | 73.18    |

## Analyses of the Ash.

| Sample No | Per Cent. Carbon | Per Cent. Sand | Per Cent. in Pure Ash.             |           |               |                |              |                |               |             |                                            |                                           |
|-----------|------------------|----------------|------------------------------------|-----------|---------------|----------------|--------------|----------------|---------------|-------------|--------------------------------------------|-------------------------------------------|
|           |                  |                | Soluble Silica (SiO <sub>2</sub> ) | Iron (Fe) | Aluminum (Al) | Manganese (Mn) | Calcium (Ca) | Magnesium (Mg) | Potassium (K) | Sodium (Na) | Phosphoric acid radicle (PO <sub>4</sub> ) | Sulphuric acid radicle (SO <sub>4</sub> ) |
| 7733      | .19              | 2.05           | 1.55                               | .15       | .26           | .16            | 27.49        | 3.30           | 11.20         | .29         | .33                                        | 1.45                                      |
|           |                  |                |                                    |           |               |                |              |                |               |             | .53                                        | 53.40                                     |
|           |                  |                |                                    |           |               |                |              |                |               |             |                                            |                                           |

No. 7518.

## NOPAL DURASNILLO BLANCO

OPUNTIA LEUCOTRICHA DC. *Revue de la Fam. d. Cact.*  
119. 1829.

A tall, erect, open branching tree, 8 to 15 feet high, with a trunk 8 to 12 in. in diameter; joints obovate, conspicuously pubescent, grayish-green; areoles circular to obovate, less than  $\frac{1}{2}$  in. apart; spicules yellow, 1-16 in. or more long; spines varying with age,  $\frac{1}{4}$  to  $\frac{1}{2}$  in. long on last year's joints but on four-year-old ones often 3 in. long, 1 to 7 in number, increasing with age, flattened, flexuous, twisted and, upon old trunks, tangled, yellow when young but turning white and giving a gray appearance to the old trunks, very weak and brittle; flowers yellow,  $1\frac{1}{2}$  to 2 in. across, with style and filaments white or greenish and stigma bright dark green; fruit light yellow throughout, short-obovate to subglobose, pubescent, formidably protected by yellow spicules and, when young, with hair-like, fugacious spines from areoles about  $\frac{1}{4}$  in. apart.

The above notes apply to the Nickels' specimen which was probably introduced from Mexico by Mrs. Nickels, although there are no distinct records. Throughout the northern plateau region, especially from Gutierrez to Aguas Calientes and San Luis Potosi, there is another distinct form growing with this one known as nopal durasnillo colorado, which has light purplish-red fruit. In all other respects the two forms are alike, except that there is a greater tendency for the

flowers of durasnillo colorado to be red and the spines shorter. The outer sepals are commonly red on the outside in both forms and this color often extends through the midribs of the inner segments also. (See Pl. IV).

Secured from the private collection of Mrs. Ann B. Nickels, Laredo, Texas, January 18, 1905, sample represented by formula 0-1-1-1, from 3 plants originating from one cutting.

#### Chemical Analyses

No. 7518.

|                            | Green. | Air Dry. |
|----------------------------|--------|----------|
| Spines .....               | .08    | .08      |
| Water .....                | 95.50  | 8.95     |
| Ash .....                  | 1.17   | 25.08    |
| Crude Protein.....         | .34    | 7.38     |
| Crude Fat.....             | .12    | 2.58     |
| Nitrogen Free Extract..... | 2.24   | 47.21    |
| Crude Fiber.....           | .68    | 13.95    |
| Organic Matter.....        | 3.33   | 70.97    |

Nos. 7593 and 7594.

#### NOPAL JOCONOXTLE

##### OPUNTIA *sp.*

A tall, open branching tree 7 to 10 feet high, with a black, scaly trunk 6 to 10 in. in diameter; joints obovate in proportion of  $7\frac{1}{2}$  x 9 in., which is a common size, gray green, with a very short, scattering pubescence; areoles  $\frac{1}{2}$  to  $\frac{3}{4}$  in. apart, broadly oval, 3-16 in. longest diameter but often  $\frac{1}{2}$  in. on edges of joints, spines upon last year's growth 4 to 10, usually 5 to 7, but increasing very much as the joints grow older, up to about the fourth year, when they begin to abraid off, very variable,  $\frac{1}{2}$  to 1 in. in length and lengthening but very little with age, white, soon mottled, flattened, weak, longer ones twisted; flowers yellow; fruits subglobose, depressed, about  $1\frac{1}{2}$  in. in longest diameter, truncate at apex, rind comparatively thick and not easily separable from pulp, yellowish-green throughout.

The species is characterized by hairy joints, weak short

spines, yellow spicules and greenish fruit with thick rind. It differs from the forms of durasnillo in being less hairy and having spines, although weak, uniformly short and erect. It also matures its fruit much later than the durasnillo group. This particular form of Joconoxtle has not been found at any other place.

No. 7593 collected at Aguas Calientes, Mexico, March 7, 1905, sample represented by formula 1-1-0-1, from 3 plants.

No. 7594 collected from the same plants at the same time, sample consisting of 20 fruits from 3 plants.

#### Chemical Analyses.

|                            | Green. |       | Air Dry. |       |
|----------------------------|--------|-------|----------|-------|
|                            | 7593   | 7594  | 7593     | 7594  |
| Sample No.....             | 7593   | 7594  | 75.93    | 75.94 |
| Spines.....                | .45    | ..... | 4.17     | ..... |
| Water.....                 | 89.42  | 92.35 | 2.60     | 2.98  |
| Ash.....                   | 2.18   | 1.13  | 20.08    | 14.40 |
| Crude Protein...           | .50    | .86   | 4.60     | 4.60  |
| Crude Fat.....             | .17    | .20   | 1.60     | 2.60  |
| Nitrogen Free Extract..... | 6.37   | 4.97  | 58.62    | 63.04 |
| Crude Fiber.....           | 1.36   | .98   | 12.50    | 12.38 |
| Organic Matter.....        | 8.40   | 6.52  | 77.32    | 82.62 |

1. Fruit.

Nos. 7621 and 7623.

#### NOPAL VINATERO

##### OPUNTIA *sp.*

An open branching tree 12 to 15 feet high, with scaly black trunk 14 in. diameter; joints narrowly obovate,  $3\frac{1}{2}$  to  $4\frac{1}{2}$  in. by 6 to 8 in., prominently pubescent, soft and silky to the touch, tuberculate, yellowish-green, turning to a light rusty brown and finally black; areoles  $\frac{7}{8}$  to  $1\frac{1}{2}$  in. apart, small, circular, obovate, about  $\frac{1}{8}$  in. in longest diameter; spicules usually invisible on upper portion of joint but protruding 1-16 in. or more from upper portion of lower areoles or occupying them entirely when no spines are present as is usually the case, brown in situ but yellow when removed; spines translucent, turning to white irregularly but with tips persistently trans-

lucent for 3 or 4 years, commonly  $\frac{1}{2}$  to  $\frac{3}{4}$  in. long, 1 to 3 on sides and 2 to 4 on edges of joints, increasing to as many as 6 on 3-year old growth, erect, divergent and but rarely recurved; flowers said by natives to be orange red; fruit oval, about  $1\frac{1}{2}$  x  $1\frac{1}{2}$  in., tuberculate, areolate, with areoles  $\frac{3}{8}$  in. apart and areas between them separated by a dark line, dull red when mature but pulp turns red before outside.

The species is easily recognized by its comparatively small narrowly obovate, pubescent, tuberculate joints.

No. 7621 collected at San Luis Potosi, Mexico, March 11, 1905, sample represented by formula 1-1-2-1, from 1 plant.

No. 7623 collected from the same tree, sample consisting of 12 fruits.

1. The species to which this name is applied about Aguas Calientes and Escarcion, Mexico, have uniformly larger joints and stouter spines. Only a few plants were found at San Luis Potosi.

#### Chemical Analyses

| Sample No.....              | Green. |       | Air Dry. |       |
|-----------------------------|--------|-------|----------|-------|
|                             | 7621   | 7623  | 7621     | 7623  |
| Spines .....                | .27    | ..... | 2.70     | ..... |
| Water .....                 | 90.45  | 85.16 | 4.74     | 6.71  |
| Ash.....                    | 2.51   | 1.56  | 24.91    | 9.78  |
| Crude Protein.....          | .65    | 1.26  | 6.46     | 7.92  |
| Crude Fat.....              | .17    | .99   | 1.70     | 6.25  |
| Nitrogen Free Extract ..... | 4.98   | 6.58  | 49.27    | 41.39 |
| Crude Fiber .....           | 1.29   | 4.45  | 12.45    | 27.95 |
| Organic Matter.....         | 7.04   | 13.28 | 70.28    | 83.51 |

1. Fruit.

Nos. 6525 and 7640.

#### PRICKLY PEAR. NOPAL

*OPUNTIA MICRODASYS* Lehm. Nov. Act. Nat. Cur.<sup>2</sup> 16: 317. 1827.

A low, prostrate or ascending plant, 2 feet or less high; joints in proportion of 4x5 in., which is a common size, obovate, conspicuously pubescent; areoles circular,  $\frac{1}{2}$  to  $\frac{3}{8}$  in. apart; spicules yellow, prominent, spreading, forming a cap-

2. This reference has not been seen.

like bunch  $\frac{1}{4}$  in. in diameter and developing anew from lower part of areole for at least 3 years, old joints often appearing with old, gray, dirty spicules above and bright new, yellow ones below; spines entirely absent; flowers yellow with white or greenish filaments and style and bright dark green 6 to 8-parted stigma; fruit small, subglobose or obovate, usually less than 1 in. long, with thin rind, green, with a blush of purple on outside but the interior greenish throughout, formidably protected by closely set areoles filled with yellow spicules.

This is one of the most common of the cultivated prickly pears of both garden and conservatory on account of the attractive appearance of its conspicuous bunches of spicules, its hardness and ease of propagation. Its small size, as well as its numerous small spicules, render it highly improbable that it will ever amount to anything as a stock food. Some forms have brown spicules and are found in some collections under the name of *O. rufida* but the latter is a very different plant.

No. 6525 collected at Alonzo, Mexico, June 10, 1904, sample represented by formula 7-2-1 + 17 small green fruits from 3 plants.

No. 7640 collected from same plants as No. 6525, March 14, 1905, sample represented by formula 1-1-1.

#### Chemical Analyses

|                            | Green. |       | Air Dry. |       |
|----------------------------|--------|-------|----------|-------|
|                            | 6525   | 7640  | 6525     | 7640  |
| Sample No. ....            |        |       |          |       |
| Spicules .....             |        |       |          |       |
| Water .....                | 84.58  | 88.12 | 6.47     | 2.80  |
| Ash .....                  | 3.57   | 2.18  | 21.65    | 17.88 |
| Crude Protein.....         | .72    | .49   | 4.38     | 4.06  |
| Crude Fat.....             | .31    | .20   | 1.90     | 1.61  |
| Nitrogen Free Extract..... | 7.53   | 7.51  | 45.65    | 61.42 |
| Crude Fiber.....           | 3.29   | 1.50  | 19.95    | 12.24 |
| Organic Matter.....        | 11.85  | 9.70  | 71.88    | 79.32 |

## Analyses of the Ash

| Sample No. | Per Cent. Carbon. | Per Cent. Sand. | Per Cent. in Pure Ash.             |           |               |                |              |                |               |             |                                            |                                           |               |                                          |
|------------|-------------------|-----------------|------------------------------------|-----------|---------------|----------------|--------------|----------------|---------------|-------------|--------------------------------------------|-------------------------------------------|---------------|------------------------------------------|
|            |                   |                 | Soluble Silica (SiO <sub>2</sub> ) | Iron (Fe) | Aluminum (Al) | Manganese (Mn) | Calcium (Ca) | Magnesium (Mg) | Potassium (K) | Sodium (Na) | Phosphoric Acid radicle (PO <sub>4</sub> ) | Sulphuric Acid radicle (SO <sub>4</sub> ) | Chlorine (Cl) | Carbonic Acid radicle (CO <sub>2</sub> ) |
| 6625       | .28               | 11.65           | 9.00                               | 1.02      | .92           | .35            | 25.00        | 3.40           | 11.50         | .22         | .98                                        | 1.73                                      | 1.26          | 39.53                                    |

Nos. 6690 and 7888.

## PRICKLY PEAR. NOPAL

OPUNTIA BASILARIS *Engelm. and Bigel. Pacif. Ry. Rep.*  
*4: 43. Pl. 13, f. 1-5. 1856.*

A low, prostrate or ascending, bluish-green to purplish plant, seldom over two joints high; joints broadly obovate to triangular and often obcordate and contracted below into a stipitate base, pubescent or nearly smooth, blue green to purplish; areoles depressed, transversely elliptical below but vertically elliptical to obovate above,  $\frac{1}{4}$  in. apart; wool tawny, scarce; spicules reddish-brown, numerous, occupying nearly the entire areole; spines none; flowers magenta, 3 in. in diameter, filaments bright red, style a little lighter and 8 or 9-parted, white or reddish tinged stigma; fruit obovate, subglobose to tuberculate, green, dry, with large, white, angular seed.

No. 6690 collected at Hackberry, Arizona, July 25, 1904, sample consisting of 6 joints of the previous year from 6 plants.

No. 7888 collected in same locality May 9, 1905, sample represented by formula 3-1, from 4 plants.



## Chemical Analyses.

|                             | Green. |       | Air Dry. |       |
|-----------------------------|--------|-------|----------|-------|
|                             | 6690   | 7888  | 6690     | 7888  |
| Sample No.....              |        |       |          |       |
| Spines.....                 |        |       |          |       |
| Water .....                 | 81.00  | 85.90 | 6.08     | 3.13  |
| Ash .....                   | 4.04   | 2.70  | 19.98    | 17.78 |
| Crude Protein.....          | .76    | .63   | 3.77     | 4.16  |
| Crude Fat .....             | .38    | .34   | 1.90     | 2.23  |
| Nitrogen Free Extract ..... | 11.43  | 9.66  | 55.52    | 63.64 |
| Crude Fiber .....           | 2.38   | 1.87  | 11.75    | 9.06  |
| Organic Matter .....        | 14.96  | 12.00 | 73.94    | 79.09 |

No. 6675.

OPUNTIA TRELEASII KERNI *n. var.*

A low prostrate or ascending, spreading species forming somewhat extensive thickets as well as growing in scattering individuals, seldom a foot high; joints 3 to 4 in. x 5 to 7 in., obovate, with contracted, stipitate base or simply ovate or even tunicate above, gray green with surface of older joints almost black, smooth or indistinctly minutely pubescent; areoles subcircular to obovate, less than  $\frac{1}{8}$  in. in diameter and about  $\frac{1}{8}$  in. apart, filled with a prominent light brown bunch of spicules  $\frac{1}{8}$  to  $\frac{1}{4}$  in. long upon last year's joints, in this year's joints they are fewer in number and surrounded by conspicuous white wool, the spicules fading in the third year to a dirty yellow; spines rather weak but persisting indefinitely without increasing in number, erect-divergent, dirty yellow with darker tips, 2 to 4 in number and very variable in length,  $\frac{1}{4}$  to  $1\frac{1}{2}$  in. long, all from lower part of areole; flowers magenta, large and showy, differing in no way from those of *O. basilaris*, with filaments bright red, style slightly tinted, stigma yellow, 6-parted; fruit obovate to subglobose, about  $1\frac{1}{4}$  x  $1\frac{1}{2}$  in., dry, with spicules and spines much like those of the joints, tuberculate, green or with a tinge of purple upon the tubercles; seeds large, angular, white.

This description is very different from the original one for *O. treleasii*, but it fits our plant, which represents the other extreme of the species described by Professor Coulter. In fact, there is in this species a complete gradation from a

perfectly spineless to a densely spiny form. Typical *O. treleasei* resembles *O. brsilaxis* rather closely but it has areoles sunken, joints more rounded at the apex, longer more prominent spicules, and a more glaucous appearance. This type form passes by almost imperceptible gradations into the variety described above. Our collections show a complete connection between *O. treleasei* and this spiny variety.

The botanical type of the variety is No. 8321 D. G. collected near Kern, California, May 27, 1906.

Collected at Bakersfield, California, July 21, 1904, sample represented by formula 4-5-1, from 5 plants.

#### Chemical Analyses.

|                            | Green. | Air Dry. |
|----------------------------|--------|----------|
| Sample No.....             | 6675   | 66.75    |
| Spines.....                | .63    | 4.34     |
| Water.....                 | 82.84  | 7.90     |
| Ash.....                   | 3.71   | 19.33    |
| Crude Protein.....         | .94    | 4.92     |
| Crude Fat.....             | .39    | 2.03     |
| Nitrogen Free Extract..... | 9.85   | 51.37    |
| Crude Fiber.....           | 2.77   | 14.45    |
| Organic Matter.....        | 13.95  | 72.77    |

No. 7734.

*OPUNTIA RUFIDA* Engelm. *Proc. Am. Acad. Arts & Sci.* 3-298. 1856.

An erect, open branching plant 3 to 5 feet high, with a distinct trunk 4 to 6 in. in diameter; joints subcircular to broadly obovate in proportion of  $7 \times 8\frac{1}{2}$  in. which is rather under size, commonly 10 in. in diameter, pubescent, gray green; areoles subcircular, slightly raised on lower side, 3-16 in. in diameter and  $\frac{3}{8}$  to 1 in. apart; wool tawny; spicules reddish-brown, in a crescentric bunch in upper portion of areole but soon surrounding it entirely, the center of the areole developing even upon oldest trunks into a cylindrical, curved or coiled structure  $\frac{1}{2}$  in. or more long, upon which the spicules develop indefinitely, often nearly covering the entire trunk;

spines entirely absent; flowers yellow to orange with red in portions exposed in the bud, which makes them appear red when closed, with filaments and style from greenish-white to orange, and stigma dark bright green, 8-parted; fruit not examined.

Our specimens correspond exactly with the type of the species in the herbarium of the Missouri Botanical Garden, but specimens of fruit have never, so far as we are aware, been collected. Our only experience with fruited forms has been from a car window between Torreon and Monterey in July, 1905. They are bright red, resembling in color those of *Opuntia stenopetala* very much from a distance. The plains form of the plant differs in many ways, though, from that growing in the foothills about Torreon, where our sample was collected. Our No. 8023 from Tizoc is a good illustration of the plains form with either subcircular or oval joints, with smaller areoles and a purplish tinge. These are smaller plants throughout than those growing upon the rocky mountain sides.

Collected at La Perla, Mexico, April 11, 1905, sample represented by formula 1-1-1, from 2 plants.

#### Chemical Analyses

|                             | Green. | Air Dry. |
|-----------------------------|--------|----------|
| Sample No.....              | 7734   | 7734     |
| Spines .....                |        |          |
| Water .....                 | 76.92  | 5.18     |
| Ash .....                   | 4.84   | 19.90    |
| Crude Protein .....         | .85    | 3.50     |
| Crude Fat .....             | .44    | 1.83     |
| Nitrogen Free Extract ..... | 12.81  | 52.56    |
| Crude Fiber .....           | 4.14   | 17.08    |
| Organic Matter .....        | 18.24  | 74.92    |

## Analyses of the Ash

| Sample No. | Per Cent. Carbon. | Per Cent. Sand. | Per Cent. in Pure Ash.             |           |               |                |              |                |               |             |                                            |
|------------|-------------------|-----------------|------------------------------------|-----------|---------------|----------------|--------------|----------------|---------------|-------------|--------------------------------------------|
|            |                   |                 | Soluble Silica (SiO <sub>2</sub> ) | Iron (Fe) | Aluminum (Al) | Manganese (Mn) | Calcium (Ca) | Magnesium (Mg) | Potassium (K) | Sodium (Na) | Phosphoric acid radicle (PO <sub>4</sub> ) |
| 7734       | .62               | .78             | 2.54                               | .46       | .15           | .67            | 34.79        | 1.66           | 3.46          | .11         | .72                                        |
|            |                   |                 |                                    |           |               |                |              |                |               |             | Sulphuric acid radicle (SO <sub>4</sub> )  |
|            |                   |                 |                                    |           |               |                |              |                |               |             | .80                                        |
|            |                   |                 |                                    |           |               |                |              |                |               |             | Chlorine (Cl)                              |
|            |                   |                 |                                    |           |               |                |              |                |               |             | Carbonic acid radicle (CO <sub>2</sub> )   |
|            |                   |                 |                                    |           |               |                |              |                |               |             | 54.17                                      |

Nos. 6576, 6577 and 7811.

**NOPALEA**<sup>1</sup> *sp.*

An erect, profusely branching shrub 5 to 8 feet high; joints small, obovate, 3x6 in., which is a common size for last year's growth, prominently tubercled, bright yellowish-green; leaves about  $\frac{3}{4}$  in. long, subulate, mucronate; areoles upon prominent tubercles, which, upon young growth, appear like white or yellowish cushions, so prominent is the wool, obovate, triangular, and perpendicular to surface of joint when young but later simply slightly raised 3-32 to  $\frac{1}{4}$  in. above surface of joint, about  $\frac{1}{4}$  in. apart; spicules yellow, not prominent; spines very numerous and formidable, erect, divergent in all directions, 4 to 12, yellowish, turning to gray, increasing but little in length or numbers after second year, slightly flattened, usually less than 1 inch long; flowers red with red filaments and style and light green, 5-parted stigma; fruit small, subglobose to obovate, red, deeply pitted at apex, tuberculate, with areoles  $\frac{1}{4}$  to  $\frac{1}{2}$  in. apart, bearing a small number of spicules and 1 to 3 spines.

This species grows very rapidly and although the joints are small it may have some value as stock food. Botanically it appears to be more closely related to *N. ouberi* than any other species but it differs considerably from the descriptions of this and no authentic material has been seen. (See Pl. III, fig. 1.)

1. This genus differs from *Opuntia* mainly in stamens and pistil being longer than the petals which are connivent about the pistil when in full bloom instead of spreading out into a bellshaped flower like the *Opuntias*.

No. 6576 secured from The Albert S. White park, River. side, California, July 7, 1904, sample represented by formula 3-3-2-1, from 3 plants.

No. 6577 secured from the same plants and on same date as No. 6576, sample consisting of 51 fruits from 4 plants. This was all previous year's fruits, which still clung to the shrubs.

No. 7811 secured from the same plants as No. 6576 April 29, 1905, sample represented by formula 1-1-1-1, from 3 plants.

### Chemical Analyses

| Sample No.....             | Green. |       |       | Air Dry. |       |       |
|----------------------------|--------|-------|-------|----------|-------|-------|
|                            | 6576   | 65771 | 7811  | 6576     | 65771 | 7811  |
| Spines .....               | 1.68   | ..... | .85   | 14.41    | ..... | 5.56  |
| Water .....                | 89.31  | 89.86 | 85.65 | 8.33     | 8.00  | 5.88  |
| Ash.....                   | 2.86   | 1.59  | 2.38  | 24.49    | 13.78 | 15.63 |
| Crude Protein.....         | .42    | .56   | .41   | 3.61     | 4.82  | 2.70  |
| Crude Fat.....             | .16    | .29   | .24   | 1.35     | 2.50  | 1.58  |
| Nitrogen Free Extract..... | 5.42   | 5.58  | 9.17  | 46.47    | 48.22 | 62.11 |
| Crude Fiber.....           | 1.84   | 2.62  | 1.86  | 15.75    | 22.68 | 12.10 |
| Organic Matter.....        | 7.83   | 9.05  | 11.97 | 67.18    | 78.22 | 78.49 |

1. Fruit.

## CANE CACTI (CYLINDROPUNTIA)

Nos. 6253, 6254, 6255, 7801, 7802, 7796, 8170a and 8170b.

## CHOLLA

OPUNTIA FULGIDA *Engelm. Proc. Am. Acad. Arts & Sci.*  
3: 306. 1856.

A low, profusely and compactly branched, symmetrical tree 4 to 6 or 8 feet high, with a black scaly trunk 3 to 6 in. in diameter; joints cylindrical or ovate,  $1\frac{1}{2}$  to  $1\frac{3}{4}$  in. in diameter but very variable in length, bright leaf green, tuberculate, with compressed tubercles having a uniform curvature above and below, completely surrounded by a dark green line; areoles obovate,  $\frac{1}{4}$  to  $\frac{5}{8}$  in. long and about  $\frac{3}{4}$  in. apart, the tissue enlarging with age and giving rise to a papillate projection  $\frac{1}{4}$  in. or less in height; wool light yellow; spicules white or light yellow, inconspicuous; spines yellowish-white, loosely tunicate with white glistening sheaths, longest  $1\frac{1}{2}$  to 2 in. with others shorter, erect-divergent, with lower more or less recurved, 4 to 8 in number upon last year's joints but increasing indefinitely for 8 or 10 years at least from the apical portion of the areolar papillum, flattened but not twisted; flowers greenish yellow; fruit ovate-obovate to subglobose, proliferous, areolate, with white or yellowish spicules, at first deeply depressed at apex but becoming flattened or even convex when fully developed, and three years old or more. (See Pl. VI, fig. 2.)

This is one of the most characteristic cacti of the southern Arizona deserts. It may grow in scattering individuals or form impenetrable thickets which are avoided by cattle except during extreme drouths. It is easily recognized by its succulent, easily separable joints and proliferous fruit. The latter remains upon the trees very often for a period of five or 6 years, fruits giving rise to flowers and subsequently to fruits year after year until a pendant branching bunch containing a score or more of fruits is formed. This is one of the most interesting characteristics of the plant. Ordinarily, fruits develop in a single year but in this and a few other species they appear to grow continuously for five years or more. While those produced from June flowers may not

**PLATE VI.—CELINDROPUNTIA OR CANE CACTI.**



**Fig. 1. (*Opuntia Versicolor*) Engelm.**



**Fig. 2. Cholla, (*Opuntia fulgida*.)**

PLATE VII—CYLINDROPUNTIA OR CANE CACTI



Fig. 1. *Opuntia spinosior*, (Engelm) Toumey.



Fig. 2. Cardenche, Goconoxtle. (*Opuntia imbricata*, Haw). D. C.



be over  $\frac{1}{2}$  in. in diameter in the fall, when three years old they may be  $1\frac{1}{2}$  in. or more in diameter.

A photographic reproduction of a fruited branch of this species will be found in Bull. 4: Pl. 6, f. 2, Bureau of Plant Industry, U. S. D. A. A photographic reproduction of a very large plant will be found in Gard. and For. 8: 325. f. 46, 1895. (See Pl. VI, fig. 2).

No. 6253 collected in northern foothills of Santa Catalina Mountains, Arizona, May 4, 1904, sample consisting of fruit from 6 plants.

No. 6254 collected at same time and place as No. 6253, sample represented by formula 0-0-6-1.

No. 6255 collected at same time and place as above, sample represented by formula 6-6.

No. 7801 collected in same locality as above April 25, 1905, sample consisting of fruit to 6 years old from 6 plants.

No. 7802 collected at same time and place as No. 7801, sample represented by formula 2-3-2, from 7 plants.

No. 7796 collected at same time and place as No. 7801, sample represented by formula 0-0-0-1-2-1, from 3 plants.

No. 8170a collected on mesa north of Helvetia, Arizona, October 8, 1905, sample consisting of spiny, largely sterile fruits.

No. 8170b fruit of 8170 analyzed without the seed.

## Chemical Analyses

|                             | Green. |       |       |       |       |       |        |        | Air Dry. |       |       |       |       |       |        |        |
|-----------------------------|--------|-------|-------|-------|-------|-------|--------|--------|----------|-------|-------|-------|-------|-------|--------|--------|
|                             | 62531  | 6254  | 6255  | 78011 | 7892  | 7796  | 8170a1 | 8170b1 | 62531    | 6254  | 6255  | 78011 | 7892  | 7796  | 8170a1 | 8170b1 |
| Sample No .....             |        |       |       |       |       |       |        |        |          |       |       |       |       |       |        |        |
| Spines .....                | 1.76   | 2.27  |       |       | 1.72  | .94   |        |        | 6.13     | 6.60  | 9.60  | 5.43  | 8.64  | 2.96  |        |        |
| Water .....                 | 83.48  | 72.63 | 78.03 | 80.29 | 81.61 | 70.33 | 82.84  | 87.17  | 4.88     | 5.60  | 6.96  | 5.43  | 7.10  | 6.19  | 5.16   | 4.55   |
| Ash .....                   | 2.79   | 3.98  | 3.36  | 3.26  | 2.21  | 2.73  | 2.70   | 1.58   | 16.05    | 13.40 | 14.25 | 15.80 | 11.10 | 8.63  | 14.99  | 11.73  |
| Crude Protein .....         | .59    | .96   | 1.30  | .56   | .96   | .95   | .63    | .47    | 3.33     | 3.29  | 5.48  | 2.70  | 4.82  | 3.00  | 3.50   | 3.50   |
| Crude Fat .....             | .36    | .48   | .35   | .47   | .29   | .43   | .51    | .27    | 2.06     | 1.46  | 1.48  | 2.24  | 1.41  | 1.36  | 2.85   | 1.98   |
| Nitrogen Free Extract ..... | 11.18  | 20.37 | 15.37 | 13.78 | 14.31 | 17.99 | 11.63  | 9.60   | 64.36    | 70.27 | 65.09 | 66.05 | 71.41 | 56.92 | 64.12  | 71.49  |
| Crude Fiber .....           | 1.60   | 1.72  | 1.59  | 1.66  | .83   | 7.56  | 1.69   | .91    | 9.23     | 5.96  | 6.75  | 7.98  | 4.16  | 23.90 | 9.38   | 6.75   |
| Organic Matter .....        | 13.73  | 23.49 | 18.61 | 16.46 | 16.28 | 20.94 | 14.46  | 11.25  | 79.07    | 91.00 | 78.80 | 78.97 | 81.90 | 86.18 | 79.85  | 83.72  |

1. Fruit.

2. Fruit minus the seed.

## Analyses of the Ash

| Sample No. | Per Cent. Carbon. | Per Cent. Sand. | Per Cent. in Pure Ash.             |           |                |                |              |                |               |             |                                               |                                              |               |                               |
|------------|-------------------|-----------------|------------------------------------|-----------|----------------|----------------|--------------|----------------|---------------|-------------|-----------------------------------------------|----------------------------------------------|---------------|-------------------------------|
|            |                   |                 | Soluble Silica (SiO <sub>2</sub> ) | Iron (Fe) | Aluminium (Al) | Manganese (Mn) | Calcium (Ca) | Magnesium (Mg) | Potassium (K) | Sodium (Na) | Phosphoric Acid<br>radicle (PO <sub>4</sub> ) | Sulphuric Acid<br>radicle (SO <sub>4</sub> ) | Chlorine (Cl) | Carbonic Acid<br>radicle (CO) |
| 6255       | .74               | 1.65            | .63                                | .21       | .53            | .09            | 24.21        | 8.10           | 11.89         | 0.00        | 2.54                                          | 2.00                                         | 1.33          | 42.73                         |

Nos. 6256 and 7800.

## CHOLLA

OPUNTIA MAMILLATA Schott. *Proc. Am. Acad. Arts & Sci.* 3: 308. 1856.

The previous numbers are the typical form of *Opuntia fulgida*, with which this species is commonly placed at present but there appears to be a difference which, although not constant, is sufficiently so to warrant our keeping the two forms separate for the purposes of this writing. We doubt whether they are sufficiently distinct to remain separate permanently. Toumey<sup>1</sup> claims that this species increases the number of its spines and decreases the size of its tubercles when grown upon the desert mesas near Tucson and becomes indistinguishable from the other form. It differs from *O. fulgida* in having larger tubercles and fewer spines.

No. 6256 collected in foothills of Santa Catalina Mountains, Arizona, May 4, 1904, sample represented by formula 5-5-5-1.

No. 7800 collected in the same locality as No. 6256, April 25, 1905, sample consisting of proliferous bunches of fruits 1 to 6 years old from 6 plants.

1. Gard. & For. 8: 324-326. 1895.

## Chemical Analyses

|                             | Green. |       | Air Dry. |       |
|-----------------------------|--------|-------|----------|-------|
|                             | 6256   | 78001 | 6256     | 78002 |
| Sample No. ....             |        |       |          |       |
| Spines .....                | .13    | .19   | .75      | 1.44  |
| Water .....                 | 88.60  | 87.85 | 6.26     | 7.63  |
| Ash .....                   | 2.93   | 1.95  | 16.75    | 14.85 |
| Crude Protein .....         | .96    | .66   | 5.48     | 5.08  |
| Crude Fat .....             | .30    | .38   | 1.70     | 2.89  |
| Nitrogen Free Extract ..... | 9.57   | 8.40  | 54.68    | 63.87 |
| Crude Fiber .....           | 2.65   | .75   | 15.13    | 5.73  |
| Organic Matter .....        | 13.47  | 10.19 | 76.99    | 77.52 |

1. Fruit.

## Analyses of the Ash

| Sample No. | Per Cent. Carbon.] | Per Cent. Sand. | Per Cent. in Pure Ash.             |           |               |                |              |                |               |             |                                               |                                              |               |                                             |
|------------|--------------------|-----------------|------------------------------------|-----------|---------------|----------------|--------------|----------------|---------------|-------------|-----------------------------------------------|----------------------------------------------|---------------|---------------------------------------------|
|            |                    |                 | Soluble Silica (SiO <sub>3</sub> ) | Iron (Fe) | Aluminum (Al) | Manganese (Mn) | Calcium (Ca) | Magnesium (Mg) | Potassium (K) | Sodium (Na) | Phosphoric Acid<br>radicle (PO <sub>4</sub> ) | Sulphuric Acid<br>radicle (SO <sub>4</sub> ) | Chlorine (Cl) | Carbonic Acid<br>radicle (CO <sub>3</sub> ) |
| 6256       | .55                | 3.57            | 1.10                               | .37       | .32           | .18            | 23.56        | 7.62           | 12.36         | .32         | 1.72                                          | 2.44                                         | 1.67          | 45.53                                       |

Nos. 6249, 6250, 7795 and 7799.

## CHOLLA

OPUNTIA BIGELOVII *Engelm. Pacif. Ry. Rep. 4: 50. Pl. 19, f. 1-7, 1956.*

A compactly and divaricately branched tree 4 to 6 feet high, with a black scaly trunk 3 to 4 in. in diameter; joints easily separable, oblong, cylindrical,  $1\frac{1}{2}$  to  $1\frac{3}{4}$  in. in diameter and 4 or 5 in. long, tuberculate, with low compressed tubercles, with lower crest gradual and upper abrupt almost perpendicular to surface of joint; leaves very small, subulate, cuspidate, about  $\frac{1}{8}$  in. long by 1-32 in. wide; areoles occupying entire upper slope of tubercle, obovate, about  $3-16 \times \frac{1}{8}$  in.,

very closely set, 3-16 to  $\frac{1}{4}$  in. apart; wool white but yellowish in situ in new growth; spicules almost white, formidable, in a truncate bunch from upper part of areole,  $\frac{1}{8}$  in. long; spines yellowish-white turning to brown, sheathed comparatively tightly, numerous, 6 to 10 on last year's joints but increasing with age until the stem is completely covered with a loose mass of them often  $\frac{1}{4}$  in. thick, the areolar tissue developing into a tubercle  $\frac{1}{4}$  in. long giving rise to new spines indefinitely, erect-divergent,  $\frac{1}{2}$  to 1 in. long; flowers greenish-yellow; fruit greenish-yellow, ovate, depressed at top, areolate like stem, with a circumscribing, dark green line completely surrounding the tubercles, areoles obovate with formidable, yellowish-white spicules and long, delicate, hair-like, fugacious, unsheathed spines.

This is the most formidably protected of any species of this genus known to us. The whole plant is literally covered with erect, divergent, sheathed spines and the joints are very easily separable. The only species with which it is likely to be confused in *Opuntia fulgida* in some of its spinier forms, but the more spiny character, smaller tubercles and non-proliferous fruits separate this readily from that species.

No. 6249 collected in foothills of Santa Rita Mountains, Ariz., April 4, 1904, sample represented by formula 8-2-2, from 2 plants.

No. 6250 collected at same time and place as No. 6249, sample consisting of last year's fruit, from 10 plants.

No. 7795 collected in same locality as above April 25, 1905, sample represented by formula 1-1-1-1, from 4 plants.

No. 7799 collected at same time and place as No. 7795, sample consisting of 28 fruits from 8 plants.

## Chemical Analyses

| Sample No.....        | Green. |       |       |       | Air Dry. |       |       |       |
|-----------------------|--------|-------|-------|-------|----------|-------|-------|-------|
|                       | 6249   | 62501 | 7795  | 77991 | 6249     | 62501 | 7795  | 77991 |
| Spines .....          | 2.51   | 1.43  | 2.58  | ..... | 11.97    | 6.00  | 18.18 | ..... |
| Water .....           | 80.17  | 77.60 | 84.75 | 85.18 | 5.30     | 5.80  | 6.63  | 5.81  |
| Ash .....             | 2.78   | 3.79  | 2.12  | 1.88  | 13.30    | 15.88 | 14.90 | 11.94 |
| Crude Protein.....    | 1.24   | 1.17  | .53   | .62   | 5.91     | 4.92  | 3.72  | 3.94  |
| Crude Fat.....        | .42    | .40   | .23   | .24   | 2.00     | 1.70  | 1.65  | 1.51  |
| Nitrogen Free Extract | 12.08  | 12.95 | 8.68  | 10.33 | 57.46    | 54.48 | 61.20 | 65.67 |
| Crude Fiber.....      | 3.36   | 4.09  | 1.69  | 1.75  | 16.03    | 17.18 | 11.90 | 11.13 |
| Organic Matter.....   | 17.05  | 18.61 | 11.13 | 12.94 | 81.40    | 73.23 | 78.47 | 83.25 |

## 1. Fruit.

Nos. 6245, 6246, 7806, 7778, 8162a and 8162b.

*OPUNTIA SPINOSIOR* (Edgelm. and Bigel.) Toumey. *Proc. Am. Acad. Arts & Sci.* 3: 307. 1856; *Bot. Gaz.* 25; 119-124. 1898.

A tree 5 to feet high with very open branching habit and a black, scaly trunk 2 to 4 in. in diameter; joints cylindrical, about  $\frac{1}{2}$  in. in diameter and of variable length, rather easily separable when young, tubercles flattened, with longest crest downward, completely surrounded by dark green lines; leaves 3 in. long and less than 1-16 in. broad at base, subulate, cuspidate; areoles on upper side of crest of tubercle oval or obovate,  $\frac{1}{8}$  in. in greatest diameter, increasing in size with age; wool tawny, varying to dark, dirty gray; spicules yellow, usually inconspicuous but sometimes 1-16 in. long; spines 8 to 12 on last year's joints but increasing with age to three times as many,  $\frac{1}{4}$  to  $\frac{3}{4}$  in. long, there being a proliferation of areolar tissue outward and upward, the spines developing from this in all directions, sheathed closely for entire length in both large and small spines but sometimes only one-half of smaller ones covered, erect-divergent with usually a few recurved, white or reddish but fading to a dirty gray; flowers purplish-red, ovary conspicuously and completely covered with tubercles and bearing, besides spicules, fugacious, hair like, unsheathed spines.

This is one of the common species of southern Arizona and has been fed to a limited extent in a few instances. It is rather woody and of less value for feeding purposes than the

cholla with which it is almost invariably associated. The description of the fruit given above applies to that which the writers have ordinarily met with in the field. When grown under favorable conditions it is much less tubercular than indicated above, indeed well developed fruits may often be found which are almost smooth. This is especially true of those which have remained upon the trees until the following season. This difference is especially noticeable in forms growing in the foothills. These are always more plump and less tubercular than those growing in less favorable situations upon the desert mesas. (See Pl. VII, f. 1.)

No. 6245 collected in northern foothills of Santa Rita Mountains, Arizona, April 30, 1904, sample represented by formula 5-5-3, from 5 plants.

No. 6246 collected at same time and place as No. 6245, sample consisting of last year's fruits.

No. 7806 collected at Tucson, Arizona, April 27, 1905, sample represented by formula 3-2-1-1, from 6 plants.

No. 7778 collected near Helvatia, Arizona, April 17, 1905, sample consisting of 16 fruits from 4 plants.

No. 8162a collected in northern foothills of Santa Rita Mountains, Arizona, October 6, 1905, sample consisting of 64 fruits from 8 plants.

No. 8162b the same as 8162a less the seed.

#### Chemical Analyses

| Sample No.                 | Green. |                   |       |                   |                    |                    | Air Dry. |                   |       |                   |                    |                    |
|----------------------------|--------|-------------------|-------|-------------------|--------------------|--------------------|----------|-------------------|-------|-------------------|--------------------|--------------------|
|                            | 6245   | 6246 <sup>1</sup> | 7806  | 7778 <sup>1</sup> | 8162a <sup>1</sup> | 8162b <sup>2</sup> | 6245     | 6246 <sup>1</sup> | 7806  | 7778 <sup>1</sup> | 8162a <sup>1</sup> | 8162b <sup>2</sup> |
| Spines .....               |        |                   | .93   |                   |                    |                    |          |                   | 3.92  |                   |                    |                    |
| Water.....                 | 73.43  | 75.27             | 77.37 | 90.97             | 77.74              | 83.04              | 4.58     | 4.95              | 4.14  | 8.51              | 4.85               | 5.13               |
| Ash.....                   | 3.31   | 3.25              | 4.32  | 2.77              | 2.97               | 3.10               | 11.90    | 12.50             | 18.28 | 14.04             | 12.71              | 17.36              |
| Crude Protein.....         | 1.58   | 1.48              | 1.16  | 1.38              | 1.74               | .55                | 5.69     | 5.69              | 4.92  | 7.01              | 7.44               | 3.06               |
| Crude Fat.....             | .47    | 1.88              | .20   | 1.12              | 1.11               | .24                | 1.67     | 7.23              | 1.40  | 5.64              | 4.75               | 1.35               |
| Nitrogen Free Extract..... | 17.26  | 12.25             | 14.88 | 9.55              | 11.50              | 11.74              | 61.91    | 47.06             | 62.91 | 48.43             | 49.10              | 65.65              |
| Crude Fiber.....           | 3.95   | 5.87              | 1.97  | 4.21              | 4.94               | 1.33               | 14.17    | 22.57             | 8.85  | 21.37             | 21.15              | 7.45               |
| Organic Matter...          | 23.26  | 21.48             | 18.31 | 16.26             | 19.29              | 13.86              | 83.52    | 82.55             | 77.55 | 82.45             | 82.44              | 77.51              |

1. Fruit.

2. Fruit less seed.

Nos. 6251, 6252, 7793 and 7797.

*OPUNTIA VERSICOLOR* Engelm. *Contr. U. S. Nat. Herb.* 3: 452, 1896.

A very loosely branched, symmetrical tree, 5 to 10 feet high, with a black or gray scaly trunk 2 to 4 in. in diameter; joints cylindrical, very variable in length, less than 1 inch in diameter for two or three years, often only  $\frac{1}{2}$  to  $\frac{3}{4}$  in., tuberculate, with compressed, low tubercles having gradual slanting crest downward but abrupt above; leaves  $\frac{1}{2}$  in. or more long and less than 1-16 in. in diameter at base, subulate, cuspidate; areoles oval, about  $\frac{1}{2}$  x 3-16 in., on upper shorter and steeper slope of tubercle; wool light yellow turning to gray and finally black with age, presenting convex surface and occupying greater part of areole; spicules red in a small inconspicuous bunch on upper side of areole, less than 1-32 in. in length, often not visible; spines numerous, 3 to 7 on last year's joints but increasing on older ones to 10 to 14 or even more, the larger ones completely and the smaller ones only partially sheathed, the distal one-half or less being covered, sheaths gray with brownish tips closely fitting and spines a translucent brown becoming dirty gray with age; flowers varying from greenish yellow through bright yellow to reddish purple with filaments green to chocolate or red and stigma yellow, 6 or 7-parted; fruit green, obovate, 1 to  $1\frac{1}{2}$  in. x  $1\frac{1}{4}$  to  $1\frac{3}{4}$  in., very tuberculate at first and retuse at apex but, when fully mature and fertile, practically smooth and truncate at top, often even convex, areolate like the stem but with smaller areoles, bearing spicules and long, delicate, fugacious, hair-like, unsheathed spines. (See Pl. VI., Fig. 1).

There is a great variation in the color of spines and flowers in this species, there appearing to be a correlation between the color of spines and flowers, the darker spined forms having more red in the composition of their flowers. In this, as in many other species, the fruit clings to the tree much longer in the lower mountain canyons than it does in more exposed situations in the lower foothills. This circumstance, it is possible, may necessarily be correlated with the difference in temperature in these situations. It is a well known fact that the temperature does not run as low close to the mountains as it does upon isolated ridges lower down in the valleys. In the lower foothills close to the Santa Cruz river the fruit of this



species falls off in early winter but here it remains attached to the tree until April. But influence of a greater supply of moisture in this situation is also to be reckoned with. It should also be noted that the fruit in this locality is very much infected by a dipterous larva which tends to cause it to revert to the vegetative condition, become more or less abnormal in many respects, and remain attached to the plants until the maturity of the insect. Such abnormal fruits are excluded from both our descriptions and our samples. (See Pl. VI. Fig. 1).

No. 6251 collected in upper foothills of Santa Catalina mountains, Arizona, May 4, 1904, sample represented by formula 4-4-4-4-4, from 6 plants.

No. 6252 collected at the same time and place as No. 6251, sample consisting of fruits from 5 plants.

No. 7793 collected in same locality as above numbers April 28, 1905, sample represented by formula 2-2-2-2, from 7 plants.

No. 7797 collected at same time and place as No. 7793, sample consisting of 24 fruits from 7 plants.

#### Chemical Analyses

| Sample No.....        | Green. |       |       |       | Air Dry. |       |       |       |
|-----------------------|--------|-------|-------|-------|----------|-------|-------|-------|
|                       | 6251   | 6252  | 7793  | 7797  | 6251     | 6252  | 7793  | 7797  |
| Spines .....          | 2.09   | ..... | .26   | ..... | 7.36     | ..... | 1.45  | ..... |
| Water .....           | 73.16  | 75.13 | 80.51 | 78.10 | 5.58     | 3.85  | 5.96  | 5.72  |
| Ash .....             | 5.69   | 3.44  | 3.02  | 2.65  | 20.00    | 17.30 | 17.49 | 11.40 |
| Crude Protein.....    | 2.24   | 1.30  | 1.30  | 1.12  | 7.88     | 5.04  | 6.28  | 4.82  |
| Crude Fat.....        | .45    | .84   | .33   | .64   | 1.60     | 3.23  | 1.56  | 2.76  |
| Nitrogen-Free Extract | 12.82  | 11.68 | 10.53 | 10.72 | 45.09    | 45.15 | 50.84 | 46.16 |
| Crude Fiber.....      | 5.64   | 7.61  | 3.70  | 6.77  | 19.85    | 29.43 | 17.85 | 29.15 |
| Organic Matter.....   | 31.15  | 21.43 | 15.86 | 19.25 | 74.42    | 82.85 | 76.55 | 82.88 |

1. Fruit.

## Analyses of the Ash

| Sample No. | Per Cent. Carbon. | Per Cent. Sand. | Per Cent. in Pure Ash. |           |               |                |              |                |               |             |                                               |                                              |               |                                             |
|------------|-------------------|-----------------|------------------------|-----------|---------------|----------------|--------------|----------------|---------------|-------------|-----------------------------------------------|----------------------------------------------|---------------|---------------------------------------------|
|            |                   |                 | Soluble Silica ) Slog) | Iron (Fe) | Aluminum (Al) | Manganese (Mn) | Calcium (Ca) | Magnesium (Mg) | Potassium (K) | Sodium (Na) | Phosphoric Acid<br>radicle (PO <sub>4</sub> ) | Sulphuric Acid<br>radicle (SO <sub>4</sub> ) | Chlorine (Cl) | Carbonic Acid<br>radicle (CO <sub>2</sub> ) |
| 6251       | .66               | 1.29            | .49                    | .26       | 0.00          | .16            | 29.53        | 4.76           | 6.59          | 1.67        | 2.49                                          | 2.55                                         | 2.38          | 45.37                                       |

Nos. 7735 D. G. and 3019, 3070a, 3070b and 3071 E. O. W.

## CANE CACTUS, CANDEL ABRUM-CACTUS

*OPUNTIA ARBORESCENS* Engelm. (Wisliz. Rep.) U. S. Sen. Miscel. Doc. No. 26 Sess. I, 30th Cong. 90, 1848.

A large, open branching tree form, 5 to 8 feet high, with trunks 3 or more inches in diameter; last year's joint commonly 6 to 8 in. long, others longer, whirled or alternate, about 1 in. in diameter, with prominent compressed tubercles about  $1\frac{1}{2}$  in. long, with curvature of upper and lower portion of crest equal; leaves subulate,  $\frac{1}{2}$  in. long by  $\frac{1}{4}$  in. wide; areoles about  $\frac{1}{4} \times 3$ -16 in. on last year's joints, situated about midway on upper slope of tubercle, gray; wool prominent, projecting slightly in smooth surface, tawny-yellow; spicules yellow, short, inconspicuous, in triangular area in upper part of areole; spines red, tunicate, with sheath white below and tinted outward, 2 to 7 on last year's joints, up to 11 or 12 on year before last's and increasing constantly as the joints grow older, erect-spreading, with lower ones recurved when they become numerous, occasionally 2 or 3 hair-like, unsheathed additional ones on edge of areole; flowers purple with obovate, spatulate, mucronate, truncate floral segments, 2 in. or more across, reddish style, dark chocolate to red filaments and white 6 or 7-parted stigma; ovary pyriform, prominently tubercled, with areoles on upper almost perpendicular side of crest, bearing 1 to 4 or 5 long, hair-like, fugacious spines, sheathed at apex only, tubercles becoming less prominent as ovary approaches maturity.

The statement made above with reference to color of spines

holds in general but many plants are found, especially northward, with yellowish spines. We are unable to distinguish any constant differences between *Opuntia arborescens* which grows in the foothills regions from Pueblo, Colorado, southward and believe the same species ranges from southern Colorado to some distance south of Torreon. See notes after next number.

No. 7735 D. G. collected at Torreon, Mexico, April 11, 1905, sample represented by formula 2-1-1-1, from 5 plants.

No. 3019 E. O. W. collected at El Rito, New Mexico, August 18, 1904, specimen consisting of joints.

No. 3070a E. O. W. collected at Agricultural College, New Mexico, December 22, 1904, sample consisting of joints.

No. 3070b E. O. W. same as 3070a, sample consisting of spines only.

No. 3071 E. O. W. collected at same time and place as No. 3070, sample consisting of fruits.

#### Chemical Analyses

| Sample No.....     | Green |       |       |       |       | Air Dry |       |       |       |       |
|--------------------|-------|-------|-------|-------|-------|---------|-------|-------|-------|-------|
|                    | 7735  | 3019  | 3070a | 3070b | 3071  | 7735    | 3019  | 3070a | 3070b | 3071  |
| Spines.....        | .65   | .86   | 2.82  | ..... | ..... | 2.27    | 7.89  | 8.94  | ..... | ..... |
| Water.....         | 72.67 | 89.97 | 69.66 | 8.73  | 66.57 | 5.26    | 7.43  | 3.85  | ..... | 4.97  |
| Ash.....           | 7.99  | 2.10  | 6.03  | 3.73  | 4.45  | 27.71   | 19.35 | 9.13  | 4.09  | 12.06 |
| Crude Protein..... | 1.58  | 1.16  | 2.97  | 1.60  | 2.62  | 5.48    | 10.73 | 9.42  | 1.75  | 7.45  |
| Crude Fat.....     | .40   | .15   | .75   | .88   | 2.53  | 1.40    | 1.35  | 2.38  | .95   | 7.15  |
| Nitrogen Free Ex.  | 13.40 | 5.43  | 16.55 | 40.89 | 15.02 | 46.43   | 50.14 | 52.44 | 36.08 | 42.67 |
| Crud. Fiber.....   | 3.96  | 1.19  | 4.03  | 44.17 | 8.82  | 13.72   | 11.00 | 12.78 | 48.40 | 25.10 |
| Organic Matter.... | 19.34 | 7.93  | 24.31 | 87.54 | 28.98 | 67.03   | 73.22 | 77.02 | 87.18 | 82.37 |

Nos. 6523, 6527, 6540, 7595 and 7597.

#### GOCONOXTLE, CARDENCHE, TUNA JUELL

*OPUNTIA IMBRICATA* (Haw) D. C. *Prodramus* 3: 47, 1828, *Cereus imbricatus* Haw. *Rev. Pl. Suc.* 70, 1821.

An open branching shrub 5 to 10 feet high, with a trunk 3 to 5 in. in diameter; joints cylindrical, oval, very variable in length and diameter, 1 to 2 by 3 to 12 in.: prominently tuber-

culate with tubercles compressed,  $\frac{3}{8}$  to  $\frac{1}{2}$  in. wide by  $1\frac{1}{2}$  in. long at base and  $\frac{1}{2}$  in. high, the furrows between the tubercles being distinctly marked by a dark green line, upper and lower curvature of crests equal; leaves  $\frac{3}{4}$  in. long by  $\frac{1}{8}$  in. in greatest diameter at base, subulate, cuspidate; areoles oval, 5-16 to  $\frac{3}{8}$  in. long, tawny, increasing in size with age; wool tawny; spicules yellowish, 1-16 in. or more long; spines white or yellowish, divergent in all directions, the most prominent centrally located in lower part of areole, about 1 in. long with smaller ones surrounding it, largest ones completely and loosely tunicate, with white glistening sheaths, but the smaller only partially sheathed with close fitting covering, 5 to 10 in number on younger joints, increasing to 20 or more on 2 and 3 year old wood; flowers purple with reddish-purple style, chocolate colored filaments and 6 or 7-parted, yellowish-white stigma; fruit oval to subglobose, remaining attached to trees 3 to 5 years and continuing to develop to 2 in. in diameter, green, at first tuberculate, but nearly smooth later, and russet after two or three years old.

This is one of the common characteristic cylindrical-jointed species of the plateau region of Mexico. It is a conspicuous plant from San Luis Potosi to Gutierrez and southward.

Like *Opuntia fulgida*, the fruit remains attached to the trees in this species for several years. One has no difficulty, however, in recognizing fruits one, two or three years old by their general appearance. The younger ones are always smaller, more tuberculate and depressed at the apex. One will usually find a series of sizes, indicating the different years' growths. Stock does not appear to disturb the fruit in the open country but the natives singe the plant with brush and feed it.

It is our judgment that *O. arborescens* Engelm. and *O. imbricata* (Haw.) DC. had better be treated as distinct species. In this treatment we consider the latter to be the form from the highlands of central Mexico. Weber was of the opinion that they should be united but he was evidently better acquainted with the central Mexican forms than those of northern Mexico and southern United States. It appears to us that the two are wholly different in fruit characters as well as in some other minor details. In *O. imbricata* the fruit remains attached

to the trees for three years or more, continuing to develop constantly into an almost smooth subglobose, fleshy russet body, while in the *O. arborescens* it is decidedly tuberculate and never remains on the trees longer than the following spring. In some cases the fruit of *O. imbricata* is also proliiferous. (See Pl. VII, Fig. 2.)

No. 6523 collected at San Luis Potosi, Mexico, June 9, 1904, sample consisting of 15 fruit from 6 plants, all over one year old.

No. 6527 collected at Alonzo, Mexico, June 10, 1904, sample represented by formula 5-4, from 5 plants.

No. 6540 collected at San Luis Potosi, Mexico, June 12, 1904, sample consisting of 15 fruits from 5 plants.

No. 7595 collected at San Luis Potosi, Mexico, March 8, 1905, sample represented by formula 2-1-1-1, from 3 plants.

No. 7597 collected at same time and place as No. 7595, sample consisting of 15 fruits from the same plants.

#### Chemical Analyses

|                         | Green. |       |       |       |       | Air Dry. |       |       |       |       |
|-------------------------|--------|-------|-------|-------|-------|----------|-------|-------|-------|-------|
| Sample No.....          | 65231  | 6527  | 65401 | 7595  | 75971 | 65231    | 6527  | 65401 | 7595  | 75971 |
| Spines.....             | .....  | 1.18  | ..... | .63   | ..... | .....    | 9.02  | ..... | 3.31  | ..... |
| Water.....              | 92.08  | 87.97 | 90.92 | 82.29 | 83.45 | 6.22     | 8.13  | 4.37  | 6.43  | 4.90  |
| Ash.....                | 1.07   | 2.29  | 1.37  | 2.79  | 1.48  | 12.70    | 17.53 | 14.43 | 14.73 | 8.48  |
| Crude Protein.....      | .46    | .70   | .58   | 1.26  | .86   | 5.48     | 5.37  | 6.13  | 6.68  | 4.92  |
| Crude Fat.....          | .38    | .33   | .56   | .31   | .79   | 4.50     | 2.50  | 5.85  | 1.66  | 5.10  |
| Nitrogen Free Extract.. | 3.68   | 6.42  | 3.66  | 11.31 | 8.90  | 43.12    | 44.97 | 38.60 | 59.74 | 51.15 |
| Crude Fiber.....        | 2.33   | 2.29  | 2.91  | 2.04  | 4.43  | 27.58    | 17.50 | 30.62 | 10.76 | 25.45 |
| Organic Matter.....     | 6.85   | 9.74  | 7.71  | 14.92 | 15.07 | 81.06    | 74.34 | 81.20 | 78.84 | 86.62 |

1. Fruit.

## Analyses of the Ash

| Sample No. | Per Cent. Carbon. | Per Cent. Sand. | Per Cent. in Pure Ash,             |           |               |                |              |                |               |             |                                            |
|------------|-------------------|-----------------|------------------------------------|-----------|---------------|----------------|--------------|----------------|---------------|-------------|--------------------------------------------|
|            |                   |                 | Soluble Silica (SiO <sub>2</sub> ) | Iron (Fe) | Aluminum (Al) | Manganese (Mn) | Calcium (Ca) | Magnesium (Mg) | Potassium (K) | Sodium (Na) | Phosphoric acid radicle (PO <sub>4</sub> ) |
| 6527       | .26               | 2.98            | 1.96                               | .31       | .27           | .25            | 25.27        | 4.56           | 12.89         | .03         | 1.73                                       |
|            |                   |                 |                                    |           |               |                |              |                |               |             | 2.25                                       |
|            |                   |                 |                                    |           |               |                |              |                |               |             | 4.65                                       |
|            |                   |                 |                                    |           |               |                |              |                |               |             | 37.84                                      |

Nos. 6565, 6566, 7852 and 7853.

*OPUNTIA PROLIFERA* Engelm. *Am. Jour. Arts. & Sci.* 142: 338. 1852.

A low, open and divaricately branched form, usually growing in tangled, impenetrable thickets, 3 to 4 feet high, with a trunk 3 to 4 in. in diameter; joints from 2 to 6 or 8 in. by 1½ to 1¾ in., very variable in length, with tubercles compressed, their upper crests slightly more abrupt than the lower, easily separable; leaves subulate, mucronate, about ¼ in. long; areoles ovate to obovate, ¼ to ½ in. by ¼ to 3-16 in.; wool short, tawny, yellow; spicules yellow, in a prominent segment in upper portion of areole, ½ in. long or less; spines 6 to 10, increasing with age to 20 or more, erect-divergent or the outer, lower recurved, yellow to reddish, loosely tunicate with sheaths light yellow below, deeper outward, about ¾ in. long; flowers scarlet purple, small, 1 in. across with filaments and style purplish tinted and 5-parted stigma yellowish-white; fruit proliferous, tuberculate, obovate to subglobose or hemispherical, or sometimes pyriform, deeply pitted at top, when young it is tuberculate and beset with long, reddish-brown, hair-like spines sheathed at their tips, these persisting for a year or more but when old the fruit is bare save for the spicules.

As mentioned in the original description and as suggested in the name, the fruit is proliferous and sterile. We have sometimes found one perfect angular, subglobose seed but only very rarely. Like *Opuntia fulgida* and *O. imbricata*, the fruits here continue to develop as long as they remain attached to the tree.

No. 6565 collected at San Diego, California, June 30, 1904, sample represented by formula 1-3-1-1½-1, from 4 plants.

No. 6566 collected at the same time and place as No. 6565, sample consisting of 22 fruits from 8 plants.

No. 7852 collected at San Diego, California, May 3, 1905, sample represented by formula 3-3-2, from 7 plants.

No. 7853 collected at same time and place as No. 7852, sample consisting of 25 fruits from 7 plants.

#### Chemical Analysis

| Sample No.....              | Green |       |       |       | Air Dry |       |       |       |
|-----------------------------|-------|-------|-------|-------|---------|-------|-------|-------|
|                             | 6565  | 6566  | 7852  | 7853  | 6565    | 6566  | 7852  | 7853  |
| Spines .....                | .34   | ..... | .46   | ..... | 2.02    | ..... | 3.19  | ..... |
| Water .....                 | 71.70 | 82.10 | 86.52 | 89.81 | 10.12   | 8.15  | 6.18  | 6.90  |
| Ash .....                   | 2.98  | 2.98  | 1.11  | 1.23  | 9.30    | 15.30 | 7.75  | 11.30 |
| Crude Protein .....         | 1.31  | .79   | 1.17  | .84   | 4.16    | 4.05  | 8.15  | 7.66  |
| Crude Fat .....             | .59   | .26   | .24   | .22   | 1.88    | 1.35  | 1.73  | 1.98  |
| Nitrogen Free Extract ..... | 17.65 | 12.54 | 9.30  | 6.96  | 56.05   | 64.35 | 64.61 | 63.48 |
| Crude Fiber .....           | 5.82  | 1.33  | 1.66  | .94   | 18.48   | 6.80  | 11.58 | 8.68  |
| Organic Matter .....        | 25.37 | 14.92 | 12.37 | 8.96  | 80.58   | 76.55 | 86.07 | 81.80 |

1. Fruits.

Nos. 6693 and 7887.

*OPUNTIA ECHINOCARPA* Engelm. and Bigel. *Pac. Ry. Rep.* 4; 49. *Pl. 18, f. 5-10, 1856.*

An open, divaricately branched, woody form 5 to 8 feet high, with a black, scaly trunk 3 to 5 in. in diameter; joints cylindrical, 1 to 1½ in. in diameter, varying in length, commonly 4 to 6 in., yellowish green, tuberculate, with tubercles slightly compressed and having long slope of crest downward, abrupt above, not easily separable; leaves subulate, cuspidate; areoles elliptical, gray but becoming dirty black, occupying entire upper slope of tubercle from crest to nearly the base; wool tawny; spicules light yellow in an unequal, small bunch in upper part of areole with occasionally a few scattering ones below, often invisible and never prominent; spines light yellow or occasionally tinged with brown at base, 14 to 18 in number and increasing very little with age, turning white to opaque and dirty black and falling away from old trunks, the

central larger ones sheathed but the outer naked, erect-divergent in all directions, with the outer especially lower ones recurved; flowers greenish yellow to deep purplish red with filaments and style greenish white to reddish tinged or even purple and stigma greenish yellow to occasionally slightly tinged with purple; fruit dry, obovate, tuberculate, depressed at apex with upper portion thickly beset with spines about  $\frac{1}{2}$  in. long, the central longer ones sheathed and the outer smaller ones naked.

This species is exceedingly hard and woody and is probably of little, if any, economic value. It is conspicuous upon the edge of the driest deserts of the Colorado Valley.

No. 6693 collected at Hackberry, Arizona, July 26, 1904, sample represented by formula 5-5-2-2, from 5 plants.

No. 7887 collected at Hackberry, Arizona, May 9, 1905, sample represented by formula 2-2-1, from 5 plants.

#### Chemical Analyses

| Sample No.            | Green. |       | Air Dry. |       |
|-----------------------|--------|-------|----------|-------|
|                       | 6693   | 7887  | 6693     | 7887  |
| Spines                | 1.62   | 1.24  | 3.88     | 4.06  |
| Water                 | 60.99  | 74.76 | 7.72     | 4.96  |
| Ash                   | 8.28   | 5.31  | 19.60    | 20.00 |
| Crude Protein         | 1.62   | 2.10  | 3.83     | 7.92  |
| Crude Fat             | .71    | .87   | 1.68     | 1.28  |
| Nitrogen Free Extract | 22.52  | 14.55 | 53.27    | 54.78 |
| Crude Fiber           | 5.88   | 2.91  | 13.90    | 10.94 |
| Organic Matter        | 30.73  | 19.93 | 72.64    | 75.08 |

Nos. 6696, 6698, 7893 and 7894 D. G. and 3008 and 3009 E. O. W.

*OPUNTIA WHIPPLEI* Engelm. and Bigel. Pac. Ry. Rep. 4: 50. Pl. 17, f. 1-4. 1856.

An ascending, low shrub growing in tangled bunches 2 to 8 feet in diameter and a foot or two high; joints cylindrical, terminal ones separating easily, whirled or congested near apex of stem, about 3 in. long and  $\frac{1}{2}$  in. in diameter, prominently tubercled, with tubercles but slightly compressed, with long crest downward, with deep, sharp furrow between and



delimited by a dark green line; areoles elliptical to obovate, extending from crest of tubercle to nearly its base, gray; wool tawny gray; spicules yellow, in small bunch in upper angle of areole, 1-16 in long, formidable, although rather inconspicuous; spines most prominent near apex of joint, 1 to  $1\frac{1}{4}$  in. long, reddish-brown at base, lighter outward, sheath white but yellow at apex, lower spine largest, recurved downward with 1 to 3 erect, divergent, short, stout ones above and 1 to 4 more delicate, radiating, unsheathed ones surrounding these larger ones; fruit green with tinge of red; obovate, tuberculate, with prominent bunch of yellow spicules 1-16 to  $\frac{1}{4}$  in. long in each areole, seldom producing fertile seed here.

This species is common on rocky slopes in this vicinity and is probably the same species as the next but on account of the difference in altitude, habit, fertility of seed and proliferation of fruit, we think it advisable to keep them separate. It is a low, woody species of doubtful value as stock food but may be fed with other species with which it grows.

No. 6696 collected at Hackberry, Arizona, July 26, 1904, sample consisting of 8 branches cut just above the ground from 8 plants.

No. 6698 collected at same time and place as No. 6696, sample consisting of fruit.

No. 7893 collected at Hackberry, Arizona, May 9, 1905, sample consisting of 4 branches from 4 plants cut just above the ground.

No. 7894 collected from same plants as No. 7893, sample consisting of 25 fruits from 5 plants.

No. 3008 E. O. W. collected in Western Socorro Co., New Mexico, July 25, 1904, sample consisting of joints.

No. 3009 E. O. W. fruits of No. 3008 E. O. W., only partially ripened.

No. 7786 collected at same time and place as last, sample consisting of 30 fruits from 6 trees.

| Sample No. | Per Cent. Carbon | Per Cent. Sand | Per Cent. in Pure Ash.             |           |               |                |              |                |               |             |                                               |                                              |               |                                             |
|------------|------------------|----------------|------------------------------------|-----------|---------------|----------------|--------------|----------------|---------------|-------------|-----------------------------------------------|----------------------------------------------|---------------|---------------------------------------------|
|            |                  |                | Soluble silica (SiO <sub>2</sub> ) | Iron (Fe) | Aluminum (Al) | Manganese (Mn) | Calcium (Ca) | Magnesium (Mg) | Potassium (K) | Sodium (Na) | Phosphoric Acid<br>radicle (PO <sub>4</sub> ) | Sulphuric Acid<br>radicle (SO <sub>4</sub> ) | Chlorine (Cl) | Carbonic Acid<br>radicle (CO <sub>2</sub> ) |
| 6244       | .37              | 1.42           | .36                                | .15       | 0.00          | .23            | 29.41        | 5.18           | 7.98          | 1.03        | 2.26                                          | 1.17                                         | 1.82          | 47.69                                       |

Nos. 6328, 7749, 7474a and 7474b.

## TASAJILLA

*Opuntia Leptocaulis* Dc. *Rev. d. 1, Fam. d. Cact. (Paris)*  
118. 1829.

An irregular, divaricatingly branched shrub 2 to 4 feet high, with a trunk 2 in. or less in diameter, usually erect but sometimes spreading; joints exceedingly variable, sometimes subglobose,  $\frac{1}{4}$  in. in diameter but usually cylindrical, with length varying from 2 in. to one foot but constrictions entirely obliterated in the axial growth, but the lateral joints, usually congested near the apex, fall off readily, indistinctly tuberculate; areoles ovate, 1-16 to  $\frac{1}{2}$  in. by 1-16 to 3-32 in.; spicules yellow, in three bunches in upper portion of areole, often but one in apex but at other times 2 a little below and to either side of this; spines tunicate, mostly single and erect, varying upon the same joint from 1-16 in. long at the base to  $2\frac{1}{2}$  in. outward; sheathes loose papery, white at base but darkening to a rich yellow or brown outward, flattened but not twisted; flowers greenish-yellow; fruit obovate, pyriform  $\frac{1}{2}$  in. in length, red, areolate, formidably protected by spicules  $\frac{1}{4}$  to  $\frac{1}{2}$  in. long by  $\frac{3}{8}$  to  $\frac{1}{2}$  in. wide.

There have been a great many species and varieties described from this group of forms based largely upon spine characters but also in one case at least on an apparent variation in the shape of the joint. Our experience throughout the entire range of this plant does not enable us to satisfactorily segregate any constant forms. It is true that the prostrate, spreading plants in pastures in the vicinity of San Antonio, Texas, and portions of the southern Arizona deserts are very different from the more erect, symmetrical forms along the Rio Grande. The variation occurs in habit as well as spine characteristics. Upon the same plant the spines vary from  $\frac{1}{4}$  to over 2 in. long. Some plants have uniformly short spines but in very few cases indeed do we find all the spines long. It seems to us that there is here an endless, confusing variation which cannot be satisfactorily and constantly recognized. It must be admitted, however, that the different forms are very different in aspects and in taxonomic features which are often considered weighty and it may be

that some of the forms are worthy of sub-specific rank but we are unable at present to recognize the dividing lines. The above description, together with our specimens, are sufficiently distinct we believe to indicate the form which we discuss.

This plant is regarded as a weed in southern Texas. The readiness with which the branches break off and are carried about by stock assists its dissemination very effectually so that in many pastures it has increased during recent years to an alarming extent. Stock will eat it, however, when the spines are properly singed off and in those pastures where the prickly pear grows a little time spent in singeing it while the pear is being fed would aid very decidedly in keeping it in check. Pacific Ry. Rep. 4: Pl. 20, f. 4 represents our plant fairly well except that ours bears an occasional long sheathed spine like fig. 2 on the same plate.

No. 6328 collected at Eagle Pass, Texas, May 10, 1904, sample consisting of 12 to 16 in. of the main stem with flowers and fruits attached, from 4 plants.

No. 7749 collected in the same locality April 12, 1905, sample consisting of 8 branches 18 in. to 2 feet long with attached branches, flowers and fruits from 8 plants.

No. 7474a collected at Encinal, Texas, January 9, 1905, sample consisting of fruits.

No. 7474b collected at the same time and place as No. 7474a, sample consisting of fruits.

#### Chemical Analysis

|                            | Green |       |        |        | Air Dry |       |        |        |
|----------------------------|-------|-------|--------|--------|---------|-------|--------|--------|
|                            | 6328  | 7749  | 7474a1 | 7474b1 | 6328    | 7749  | 7474a1 | 7474b1 |
| Sample No.....             | 6328  | 7749  | 7474a1 | 7474b1 | 6328    | 7749  | 7474a1 | 7474b1 |
| Spines .....               | 1.39  | 1.43  | .....  | .....  | 4.19    | 4.06  | .....  | .....  |
| Water .....                | 66.89 | 66.64 | 75.42  | 70.63  | 6.05    | 5.34  | 6.70   | 7.50   |
| Ash .....                  | 8.21  | 5.90  | 3.15   | 3.16   | 24.80   | 16.75 | 11.95  | 11.98  |
| Crude Protein.....         | 1.88  | 2.11  | 1.27   | 1.27   | 5.69    | 6.00  | 4.82   | 4.93   |
| Crude Fat .....            | .87   | .67   | 1.54   | 1.59   | 2.63    | 1.92  | 5.85   | 6.06   |
| Nitrogen Free Extract..... | 12.77 | 16.37 | 14.73  | 14.23  | 38.53   | 46.40 | 55.93  | 54.49  |
| Crude Fiber.....           | 7.38  | 8.31  | 3.89   | 4.12   | 22.30   | 23.59 | 14.75  | 15.06  |
| Organic Matter.....        | 22.90 | 27.46 | 21.43  | 21.21  | 69.15   | 77.91 | 81.35  | 80.52  |

1. Fruits.

## Analysis of the Ash

| Sample No. | Pet cent. Carbon | Per cent. Sand | Per Cent. in Pure Ash              |           |               |                |              |                |               |             |                                            |                                           |               |                                          |
|------------|------------------|----------------|------------------------------------|-----------|---------------|----------------|--------------|----------------|---------------|-------------|--------------------------------------------|-------------------------------------------|---------------|------------------------------------------|
|            |                  |                | Soluble Silica (SiO <sub>2</sub> ) | Iron (Fe) | Aluminum (Al) | Manganese (Mn) | Calcium (Ca) | Magnesium (Mg) | Potassium (K) | Sodium (Na) | Phosphoric Acid radicle (PO <sub>4</sub> ) | Sulphuric Acid radicle (SO <sub>4</sub> ) | Chlorine (Cl) | Carbonic Acid radicle (CO <sub>3</sub> ) |
| 5328       | .21              | 1.14           | 1.25                               | .20       | .19           | .27            | 33.98        | 2.28           | 4.44          | .13         | .69                                        | 1.35                                      | .57           | 53.54                                    |

No. 7503.

## TASAJILLA

OPUNTIA LEPTOCAULIS DC. *Rev. d. l. Fam. d. Cact. (Paris) 118. 1829.*

Many varieties have been described under this species. The one which we have here is the yellow fruited variety which was originally described by Dr. Engelmann as *Opuntia vaginata* from the type specimens of Dr. Wislizenus, collected in 1846. Our plant, however, differs very decidedly from the type in having much fewer spines. Indeed, the long sheathed spines are rare upon our plant, which is a large one 4 feet high. We can distinguish no difference between this and No. 7474, abundant in this locality excepting in color of fruit.

The yellow fruited from is common on the Rio Grande at Laredo but there it is a more symmetrical shrub with an abundance of the long, loosely sheathed, yellow spines.

Collected at Encinal, Texas, January 14, 1905, sample consisting of fruit from one plant.

## Chemical Analyses

| 75031                      | Green | Air Dry. |
|----------------------------|-------|----------|
| Spines .....               | ..... | .....    |
| Water .....                | 76.14 | 6.15     |
| Ash.....                   | 4.28  | 16.85    |
| Crude Protein.....         | 1.25  | 4.93     |
| Crude Fat.....             | 1.44  | 6.45     |
| Nitrogen Free Extract..... | 13.55 | 53.29    |
| Crude Fiber .....          | 3.13  | 12.83    |
| Organic Matter.....        | 19.57 | 77.00    |

## 1. Fruit.

Nos. 7628 and 7629.

## TASAJILLA

OPUNTIA KLEINIAE DC. *Rev. d. l. Fam. d. Cact. (Paris)*  
118. 1829.

An open, widely branching shrub 3 to 5 feet high, erect, often growing in tangled thickets but more commonly in isolated impenetrable bunches; joints cylindrical,  $\frac{3}{8}$  to  $\frac{1}{2}$  in. in diameter, varying from short and globular to a foot in length, the central axial ones being firmly attached and the laterals, especially the shorter ones, very easily separable, slightly tuberculate, with low, gradually descending crest below but more abrupt above, not compressed and not over  $\frac{1}{4}$  in. high, usually about 1-16 in. and entirely disappearing in old wood; leaves small, subulate,  $\frac{1}{2}$  to 3-16 in. long, pointed or often nearly circular in vertical section; areoles obovate-triangular; wool tawny; spicules reddish-brown, 1-16 in. long, commonly inconspicuous; spines long, formidable, loosely sheathed, yellowish, straw color or darker, circular or slightly flattened in cross section, usually single but sometimes three or four and often one or two smaller ones accompanying the large ones in lower angle of areole, erect, almost perpendicular to the joint; flowers pink, about  $1\frac{1}{2}$  in. across when fully expanded with filaments and style pinkish and stigma white; fruit red, persisting for one or two years, obovate or ovate, slightly tuberculate but almost smooth when mature, especially when containing an abundance of fertile seed.

This species has two well marked forms in this locality

which are comparable with two similar forms of *Opuntia leptocaulis* of southwestern Texas. The one described here is the more open branching of the two which produces red, fertile fruit. The other is more prolific in the production of both fruit and branches and is seldom fertile. This plant we consider to be the more typical form.

No. 7628 collected at San Luis Potosi, Mexico, March 12, 1905, sample consisting of 4 stems with lateral branches 2 feet long from 4 plants.

No. 7629 collected at same time and place, sample consisting of 40 fruits from 4 plants.

#### Chemical Analyses

| Sample No.....             | Green. |       | Air Dry. |       |
|----------------------------|--------|-------|----------|-------|
|                            | 7628   | 7629  | 7628     | 7629  |
| Spines .....               | 2.76   | ..... | 9.70     | ..... |
| Water .....                | 72.96  | 89.23 | 4.90     | 6.65  |
| Ash.....                   | 8.21   | 2.12  | 11.30    | 18.33 |
| Crude Protein.....         | 2.10   | .75   | 7.40     | 7.40  |
| Crude Fat .....            | .59    | .85   | 2.08     | 2.99  |
| Nitrogen Free Extract..... | 14.47  | 6.29  | 50.12    | 53.68 |
| Crude Fiber. ....          | 6.88   | 1.26  | 24.20    | 10.95 |
| Organic Matter .....       | 24.84  | 8.66  | 83.80    | 75.02 |

1. Fruit.

Nos. 7630 and 7631.

#### OPUNTIA *sp.*

An erect plant resembling in some of its smaller forms the habit of *Opuntia kleiniae* but entirely different, suggesting in some respects both the latter and the large *Cylindropuntia* (*O. imbricata* Haw.) of this region; very open branching, 4 to 6 feet high, with a trunk 3 or 4 in. in diameter; joints cylindrical, about  $\frac{1}{2}$  in. in diameter and of various lengths, the terminal ones varying between 3 and 8 inches, tuberculate, with tubercles flattened, with long crest downward and separated by a dark green line completely surrounding each one; areoles oblong, about  $\frac{1}{4} \times \frac{3}{8}$  in., extending from crest to nearly the base of the tubercle; wool gray in situ, tawny when removed; spicules brown in small bunch 1-16 in. long in upper edge of

areole; spines tunicate with yellow sheath, which is usually darker toward tip, flattened, tinted with red, 2 to 6 in number, with central which is the largest, about 1 in. long, others varying to as low as  $\frac{1}{4}$  in., the central ones erect, others divergent; fruit globular,  $1\frac{1}{4}$  in. in diameter, practically smooth when mature, but the tubercles which are plainly visible in young specimens usually more or less outlined, having areoles nearly circular or slightly obovate, about  $\frac{1}{8}$  in. greatest diameter, with a lenticular bunch of spicules above, nearly  $\frac{1}{8}$  in. long and when young, bearing a few long, fugacious, hair-like spines, all seen having depressed umbilicus.

In the locality where collected this species is not at all abundant. In many of its characters, especially in size, it is midway between *Opuntia imbricata* and *Opuntia kleiniae*.

No. 7630 collected near San Luis Potosi, Mexico, March 12, 1905, sample represented by formula 3-2-1, from 2 plants.

No. 7631 collected at the same time and place, sample consisting of 20 fruits from 2 plants.

#### Chemical Analysis

|                            | Green |       | Air Dry |       |
|----------------------------|-------|-------|---------|-------|
|                            | 7630  | 7631  | 7630    | 7631  |
| Sample No.....             | 7630  | 7631  | 7630    | 7631  |
| Spines.....                | .25   | ..... | 1.04    | ..... |
| Water.....                 | 77.26 | 86.00 | 7.15    | 7.09  |
| Ash.....                   | 3.75  | 3.14  | 15.32   | 20.85 |
| Crude Protein.....         | .75   | .53   | 8.07    | 3.50  |
| Crude Fat.....             | .54   | .43   | 2.20    | 2.45  |
| Nitrogen Free Extract..... | 13.68 | 9.07  | 55.86   | 53.56 |
| Crude Fiber.....           | 4.02  | 1.83  | 16.40   | 12.15 |
| Organic Matter.....        | 18.99 | 10.86 | 77.53   | 72.06 |

#### 1. Fruit.

Nos. 7601 and 7649.

#### CLAVELINA (At Ypina)

OPUNTIA TUNICATA Hort. Berol. ex-Pfeiff. Enum. Cact. 170. 1837.

A low, erect or ascending plant a foot or two high, forming large clumps 2 to 4 feet in diameter, the whole presenting a glistening, silvery white appearance; joints cylindrical, 1 in. or



less in diameter and varying from 6 to 8 or 10 in. long for the axial to 2 or 3 in. for the lateral, the latter being very easily separable, prominently tuberculate, with tubercles  $\frac{3}{8}$  in. high by  $1\frac{1}{2}$  in. long by  $\frac{3}{8}$  in. wide, surrounded by a sharp furrow marked by a rather indistinct dark green line, upper slope more abrupt than the lower; areoles narrowly oblong, 3-16 in. by  $\frac{1}{2}$  in. with wool protruding 1-16 in. and its surface sub-areolate; spicules white, in a comparatively small, lenticular area in upper part of areole protruding not over 1-16 in.; wool white; spines long, white, conspicuous, 6 to 10 in number, erect-divergent in all directions, the lower and smaller ones curved backward against the tubercle, longest 2 to  $2\frac{1}{2}$  in., with loose, somewhat saccate, white, glistening sheath contracted at the very base, all completely tunicate, triangular-flattened, about 1-16 in. in diameter, with sheath  $\frac{1}{2}$  in. distinctly annular, horn-like; flowers greenish-yellow; fruit obovate, with low tubercles, prominent triangular areoles, white prominent spicules  $\frac{1}{2}$  in. long surrounding upper one-third to one-half of areole, the lower ones having 1 to 3 sheathed spines often an inch long like those of stem, yellowish-green, with very mucilaginous pulp.

This plant occasionally has red spines but even then the sheaths are white, the spines showing dark or reddish through them. Sometimes one will find white or yellowish-white and red spines on the same plant and even on the same stem. This is a very conspicuous and characteristic plant of the highlands of Mexico, so admirably protected by spines that no animal can molest it. In the State of San Luis Potosi there are large areas where it is difficult for a man to travel on account of the abundance of this species. A recognizable photographic reproduction of it can be found in "The Garden" 62: 425. 1902.

No. 7601 collected at San Luis Potosi, Mexico, March 9, 1905, sample represented by formula  $2\frac{1}{2}$ , from 3 plants.

No. 7649 collected at Alonzo, Mexico, March 14, 1905, sample consisting of 24 fruits from 3 plants.

## Chemical Analyses

|                            | Green. |       | Air Dry. |       |
|----------------------------|--------|-------|----------|-------|
|                            | 7601   | 76491 | 7601     | 76491 |
| Sample No.....             | 7601   | 76491 | 7601     | 76491 |
| Spines.....                | 8.79   | ..... | 39.58    | ..... |
| Water.....                 | 79.34  | 82.52 | 7.00     | 7.40  |
| Ash.....                   | 5.17   | 3.33  | 23.25    | 17.64 |
| Crude Protein.....         | 1.17   | .83   | 5.26     | 4.34  |
| Crude Fat.....             | .36    | .95   | 1.56     | 5.03  |
| Nitrogen Free Extract..... | 11.88  | 9.72  | 58.58    | 51.51 |
| Crude Fiber.....           | 2.09   | 2.65  | 9.40     | 14.04 |
| Organ Matter.....          | 15.49  | 14.15 | 99.75    | 74.96 |

## 1. Fruit.

Nos. 3022 and 3026 E. O. W.

OPUNTIA CLAVATA Engelm. *U. S. Sen. Miscel. Doc. No. 26, 30th Cong. 1st Sess. (Wisliz. Rep.) 95. 1848.*

This low, prostrate, spreading, clavate-jointed *Cylindropuntia* with abundant yellow spicules and flat, slightly recurved, unsheathed spines can scarcely ever become of any economic value except it be in a limited way in certain ornamental plantings. Its flat, recurved spines, bright yellow flowers and peculiar whorled arrangement of the spicules around the large white wool area of the areoles of the fruit render it rather attractive. Upon the native range country it is probably detrimental occupying ground that might be occupied by grasses.

No. 3022 E. O. W. collected at Tesuque, New Mexico, Aug. 20, 1904, sample consisting of joints.

No. 3026 E. O. W. collected at Carizozo, New Mexico, Aug. 27, 1904, sample consisting of fruit.

## Chemical Analysis

|                            | Green |       | Air Dry |        |
|----------------------------|-------|-------|---------|--------|
|                            | 3022  | 30261 | 3022    | 30.261 |
| Sample No.....             |       |       |         |        |
| Spines.....                | 1.84  | ..... | 6.32    | .....  |
| Water.....                 | 72.54 | 78.17 | 6.10    | 8.25   |
| Ash.....                   | 9.56  | 6.99  | 32.03   | 29.50  |
| Crude Protein.....         | 1.47  | 2.78  | 5.04    | 11.72  |
| Crude Fat.....             | .53   | .75   | 1.70    | 2.15   |
| Nitrogen Free Extract..... | 11.65 | 7.08  | 41.73   | 29.53  |
| Crude Fiber.....           | 4.25  | 4.23  | 13.40   | 17.35  |
| Organic Matter.....        | 17.90 | 14.84 | 61.87   | 62.25  |

1. Fruit.

## MISCELLANEOUS SPECIES

Nos. 8173a and 8173b D. G. and 3068 and 3072 E. O. W.

VIZNAGA. NIGGER HEAD. BARREL CACTUS

ECHINOCACTUS WISLIZENI *Engelm. U. S., Sen. 30th 1st Cong. Sess., Miscel. Doc. No. 26 (Wisliz. Rep.) 96. 1848.*

This species is typical of a large group of desert plants, growing almost invariably in scattering individuals from the Organ Mountains of New Mexico southwestward to Lower California and southward through the highlands of Mexico. Like many other species, they are not abundant enough to furnish any great amount of stock feed. There are instances on record, however, where they have been used in seasons of great drouth. Mr. C. R. Orcutt informs us that these species have been fed in Lower California to some extent. *Echinocactus orcutti* especially abundant in places and flocks of sheep have been kept alive during severe drouths by having these plants cut down and slashed open with a machete for them to feed upon. Detailed drawings of this species will be found in U. S. & Mex. Bound Sur. 2: Pl. 3, f. 1-2, 1859.

No. 8173a collected near Tucson, Arizona, October 7, 1905, sample consisting of seed from several plants.

No. 8173b collected at same time and place and consisting of the fruit minus the seed.

No. 3068 E. O. W. collected at Agricultural College, New Mexico, December 22, 1904, sample consisting of sections of the trunk of the plant.

No. 3072 E. O. W. collected at same time and place, sample consisting of fruit of the same plants as the above.

#### Chemical Analyses

| Sample No. ....       | Green. |        |       |       | Air Dry. |        |       |       |
|-----------------------|--------|--------|-------|-------|----------|--------|-------|-------|
|                       | 8173a1 | 8173b2 | 3068  | 30723 | 8173a1   | 8173b2 | 3068  | 30723 |
| Spines .....          |        |        | .62   |       |          |        | 7.90  |       |
| Water .....           | 8.59   | 94.14  | 87.81 | 78.26 | 8.38     | 6.50   | 4.56  | 4.15  |
| Ash .....             | 3.09   | .96    | 1.70  | 1.47  | 3.10     | 13.67  | 13.33 | 6.50  |
| Crude Protein.....    | 10.92  | .63    | .71   | 2.80  | 10.94    | 10.06  | 5.58  | 12.33 |
| Crude Fat.....        | 15.46  | .06    | .13   | 2.50  | 15.50    | .95    | 1.06  | 11.03 |
| Nitrogen Free Extract | 36.49  | 3.03   | 7.49  | 9.56  | 36.65    | 50.24  | 58.53 | 42.14 |
| Crude Fiber.....      | 25.37  | 1.16   | 2.16  | 5.41  | 25.43    | 18.58  | 16.95 | 23.85 |
| Organic Matter.....   | 88.31  | 4.90   | 10.49 | 20.27 | 88.52    | 79.23  | 82.11 | 89.35 |

1. Fruit without the seed.

2. Seed.

3. Fruit.

Nos. 6331 and 7748.

#### PITALLA, MEXICAN STRAWBERRY

*ECHINOCEREUS ENNEACANTHUS* Engelm. Wislitz. Rep. U. S. Sen. Misc. Doc. No. 26, 30th Cong. 1st Sess. 111. 1848.

This is a low plant growing in hemispherical clusters of erect, spiny columns less than one foot high and 12 to 18 in. in diameter. It is exceedingly abundant in the valley of the Rio Grande in Texas and adjacent Mexico. Its application in feeding stock is very limited although in a few localities where it grows thick enough it can be fed by singeing like the pear of the same region. Dr. Engelmann subsequently figured this in U. S. & Mex. Bound, Sur. Pl. 49 1859.

No. 6331 collected at Eagle Pass, Texas, May 10, 1904; sample consisting of 8 pieces cut near the surface of the ground from as many plants.

No. 7748 collected at Eagle Pass, Texas, April 12, 1905, sample consisting of 5 pieces cut in the same way from as many plants.

## Chemical Analyses

| Sample No.            | Green. |       | Air Dry. |       |
|-----------------------|--------|-------|----------|-------|
|                       |        |       |          |       |
| Sample No.            | 6331   | 7748  | 6331     | 77.48 |
| Spines                | .52    | .88   | 3.33     | 3.17  |
| Water                 | 85.23  | 88.72 | 4.80     | 6.08  |
| Ash                   | 2.76   | 1.18  | 17.78    | 9.82  |
| Crude Protein         | 1.22   | 1.01  | 7.88     | 8.43  |
| Crude Fat             | .27    | .23   | 1.77     | 1.91  |
| Nitrogen Free Extract | 9.37   | 8.08  | 60.44    | 67.27 |
| Crude Fiber           | 1.14   | .78   | 7.33     | 6.54  |
| Organic Matter        | 12.01  | 10.10 | 77.42    | 84.15 |

## Analyses of the Ash

| Sample No. | Per Cent. Carbon | Per Cent. Sand | Per Cent. in Pure Ash.             |           |               |                |              |                |               |             |                                            |                                           |               |                                          |
|------------|------------------|----------------|------------------------------------|-----------|---------------|----------------|--------------|----------------|---------------|-------------|--------------------------------------------|-------------------------------------------|---------------|------------------------------------------|
|            |                  |                | Soluble Silica (SiO <sub>2</sub> ) | Iron (Fe) | Aluminum (Al) | Manganese (Mg) | Calcium (Ca) | Magnesium (Mg) | Potassium (K) | Sodium (Na) | Phosphoric acid radicle (PO <sub>4</sub> ) | Sulphuric acid radicle (SO <sub>4</sub> ) | Chlorine (Cl) | Carbonic acid radicle (CO <sub>2</sub> ) |
| 6831       | .26              | 3.31           | .80                                | .31       | .13           | .09            | 22.68        | 5.07           | 16.61         | .62         | 1.20                                       | 2.35                                      | 2.90          | 42.63                                    |

Nos. 6526 and 7644.

## PITALLA

*ECHINOCEREUS ACIFER* Lem. *Cact. Gen. Nov. Spec. Nov.* 57, 1839.

This species has very much the same general habit as *Echinocereus enneacanthus*. It is exceedingly abundant in the vicinity where collected, forming large hemispherical, succulent bunches, one foot high and two feet in diameter.

No. 6526 collected at Alonzo, Mexico, June 10, 1904, sample consisting of 5 columnar pieces cut off close to the ground from 5 plants.

No. 7644 collected in the same locality March 14, 1905, sample consisting of similar specimens from 3 plants.

#### Chemical Analysis

|                            | Green |       | Air Dry |       |
|----------------------------|-------|-------|---------|-------|
|                            |       |       |         |       |
| Sample No.....             | 6526  | 7644  | 6526    | 7644  |
| Spines.....                | .92   | 2.55  | 14.29   | 30.96 |
| Water.....                 | 93.90 | 92.32 | 5.63    | 6.87  |
| Ash.....                   | 1.27  | 1.07  | 19.65   | 27.30 |
| Crude Protein.....         | .74   | 1.07  | 11.39   | 12.96 |
| Crude Fat.....             | .11   | .14   | 1.66    | 1.75  |
| Nitrogen Free Extract..... | 3.12  | 4.25  | 48.30   | 51.42 |
| Crude Fiber.....           | .86   | .55   | 13.38   | 6.70  |
| Organic Matter.....        | 4.83  | 6.01  | 74.72   | 72.83 |

Nos. 6697 and 7895.

#### PITALLA

*Echinocereus Mojavensis* (Engelm.) Rumpler. Forster's Handbuch d. Cact. 803. 1886. *Cereus Mojuvensis* Engelm, Pacific. Ry. Rep. 4: 33 in text but *C. bigelovii* in Pl. 4, f. 9. 1856.

This is a somewhat conspicuous species growing in caespitose, hemispherical masses 8 to 12 in. high, on rocky hill-sides, having much the same general habit as *Echinocereus enneacanthus*. Its succulence and abundance in certain limited localities would enable its being fed in connection with other large species of prickly pear with which it usually occurs.

No. 6697 collected at Hackberry, Arizona, July 25, 1904, sample consisting of one column cut 2 inches above the ground from each of 6 plants.

No. 7895 collected at Hackberry, Arizona, May 9, 1905, sample consisting of 4 columns cut close to the ground, from 4 plants.

## Chemical Analysis

|                            | Green |       | Air Dry |       |
|----------------------------|-------|-------|---------|-------|
|                            |       |       |         |       |
| Sample No.....             | 6697  | 7896  | 6697    | 7896  |
| Spines.....                | 2.99  | 3.66  | 9.09    | 28.57 |
| Water.....                 | 69.70 | 87.96 | 8.00    | 5.98  |
| Ash.....                   | 3.84  | 1.06  | 11.65   | 8.33  |
| Crude Protein.....         | 2.88  | .94   | 7.22    | 7.34  |
| Crude Fat.....             | .49   | .42   | 1.48    | 3.27  |
| Nitrogen Free Extract..... | 19.73 | 8.32  | 59.90   | 64.98 |
| Crude Fiber.....           | 3.87  | 1.30  | 11.75   | 10.15 |
| Organic Matter.....        | 26.46 | 10.98 | 80.35   | 85.69 |

## No. 7807.

ECHINOCEREUS FENDLERI (?) (*Engelm.*), *Rumpler. Forster's Handb. d. Cact., 801, 1886: Mem. Am. Acad. 4: 51, 1849.*

This is another low, cespitose species having much the same habit as *Echinocereus enneacanthus* but differing in many botanical details. It is common upon the deserts and abundant in places in the foothills in the Santa Cruz valley of Arizona and adjacent Sonora. It can be fed the same as the other closely related species mentioned above. It appears to differ slightly from *E. fendleri* and we are doubtful about its identity.

Collected near Tucson, Arizona, April 27, 1905, sample consisting of 4 columns cut close to the ground, from 4 plants.

## Chemical Analysis

|                            | Green | Air Dry |
|----------------------------|-------|---------|
|                            |       |         |
| Spines.....                | 2.35  | 20.00   |
| Water.....                 | 88.79 | 4.50    |
| Ash.....                   | 1.78  | 15.13   |
| Crude Protein.....         | .48   | 4.05    |
| Crude Fat.....             | .11   | .90     |
| Nitrogen Free Extract..... | 7.88  | 67.28   |
| Crude Fiber.....           | .96   | 8.14    |
| Organic Matter.....        | 9.43  | 80.87   |

Nos. 6561, 6699 and 7805.

**SAGUARRO, GIANT CACTUS, GIANT CEREUS, ETC.***CEREUS GIGANTEUS Engelm. Emory's Rep. of Mil. Rec. 195. 1848.*

This familiar and conspicuous giant cactus of Arizona and adjacent Mexico may be fed to stock with very little difficulty. All the preparation necessary is the chopping up of the plant sufficiently so that animals can get at the pulpy interior. The plant is neither abundant nor rapid enough in its growth to be of any great economic importance, excepting as a temporary expedient in tiding over a period of extreme drouth. Illustrations of this are common. A very diagrammatic drawing occurs in U. S. & Mex. Bound. Sur. 2: Pl. O. and photographic reproductions in Bull. 4: Pl. 2 of the Bureau of Plant Industry, U. S. D. A.

No. 6561 collected at Tempe, Arizona, June 27, 1904, sample consisting of fruits from 16 plants.

No. 6699 collected at Tucson, Arizona, July 28, 1904, sample consisting of 4 triangular sections 3 or 4 inches thick, taken from the periphery to the center of the columnar stem, including 3 ribs 4 feet from the ground in plants 7 to 9 feet high.

No. 7805 collected at Tucson, Arizona, April 26, 1905, sample consisting of 3 triangular sections taken from the periphery to the center, including 2 ribs 2 inches thick, from 3 plants similar to those of No. 6699.

**Chemical Analyses**

|                            | Green. |       |       | * Air Dry. |       |       |
|----------------------------|--------|-------|-------|------------|-------|-------|
|                            | 6561   | 6699  | 7805  | 6561       | 6699  | 7805  |
| Sample No.....             | 6561   | 6699  | 7805  | 6561       | 6699  | 7805  |
| Spines .....               |        | .92   | .28   |            | 6.63  | 3.41  |
| Water .....                | 91.62  | 87.31 | 92.36 | 5.88       | 8.96  | 5.80  |
| Ash .....                  | .98    | 2.20  | 1.30  | 11.05      | 15.75 | 15.98 |
| Crude Protein.....         | 1.05   | .81   | .67   | 11.83      | 5.80  | 8.28  |
| Crude Fat.....             | .61    | .17   | .16   | 6.86       | 1.20  | 1.94  |
| Nitrogen Free Extract..... | 3.64   | 8.07  | 4.45  | 40.73      | 57.92 | 54.96 |
| Crude Fiber.....           | 2.10   | 1.44  | 1.06  | 23.65      | 10.35 | 13.05 |
| Organic Matter.....        | 7.40   | 10.49 | 6.34  | 83.07      | 75.27 | 78.22 |

1. Fruit.



## Analyses of the Ash

| Sample No. | Per Cent. Carbon | Per Cent. Sand | Per Cent. in Pure Ash.             |           |               |                |              |                |               |             |                                            |                                           |               |                                          |
|------------|------------------|----------------|------------------------------------|-----------|---------------|----------------|--------------|----------------|---------------|-------------|--------------------------------------------|-------------------------------------------|---------------|------------------------------------------|
|            |                  |                | Soluble Silica (SiO <sub>2</sub> ) | Iron (Fe) | Aluminum (Al) | Manganese (Mn) | Calcium (Ca) | Magnesium (Mg) | Potassium (K) | Sodium (Na) | Phosphoric Acid radicle (PO <sub>4</sub> ) | Sulphuric Acid radicle (SO <sub>4</sub> ) | Chlorine (Cl) | Carbonic Acid radicle (CO <sub>2</sub> ) |
| 6690       | .17              | .44            | .87                                | .30       | .07           | .15            | 31.64        | 5.78           | 6.66          | 0.00        | .88                                        | 4.12                                      | 3.32          | 41.06                                    |

Nos. 6518 and 7622.

## GARRAMBULLOS

**CEREUS GEOMETRIZANS** *Mar. Mart. Pfeiff. Enum. Cact. 90. 1837.*

So different from the majority of the species of this genus, this one forms a handsome, symmetrical tree with a compact crown and well marked trunk a few feet long. It is one of the most attractive of the species of the genus, so far as its vegetative state is concerned, but the flowers are comparatively small and unattractive. It is abundant in the foothills and plains, especially in the vicinity of San Luis Potosi.

No. 6518 collected at Bocas, Mexico, June 9, 1904; sample consisting of 3 terminal pieces from 3 branches of 3 trees, ranging from 3 to 10 inches in length.

No. 7622 collected at San Luis Potosi, Mexico, March 11, 1905, sample consisting of sections from branches of 2 trees not over 18 inches from apex.

## Chemical Analyses

|                             | Green. |       | Air Dry. |       |
|-----------------------------|--------|-------|----------|-------|
|                             | 6518   | 7598  | 6518     | 7598  |
| Sample No.....              | 6518   | 7598  | 6518     | 7598  |
| Spines .....                | .34    | .80   | 2.02     | 5.74  |
| Water .....                 | 84.77  | 86.92 | 10.80    | 5.92  |
| Ash .....                   | 2.40   | 1.74  | 14.05    | 12.50 |
| Crude Protein.....          | .79    | .61   | 4.60     | 4.38  |
| Crude Fat .....             | .50    | .66   | 3.43     | 4.75  |
| Nitrogen Free Extract ..... | 9.47   | 7.60  | 55.52    | 54.65 |
| Crude Fiber .....           | 1.98   | 2.47  | 11.60    | 17.80 |
| Organic Matter.....         | 12.83  | 11.34 | 75.15    | 81.58 |

Nos. 6512 and 7598.

## ORGANO

*CEREUS MARGINATUS* DC. *Rev. d. l. Fam. d. Cact. (Paris)*  
116, 1829.

This columnar, branchless cereus grows to a height of 15 feet or more and is extensively cultivated for hedges and fences in the plateau region of Mexico. It very seldom branches excepting as a result of injury to the apex of the columnar, ribbed stem.

No. 6512 collected at San Luis Potosi, Mexico, June 8, 1904 samples consisting of the tops of 2 medium sized branches from 2 plants.

No. 7598 collected at San Luis Potosi, Mexico, March 8, 1905, sample consisting of one section from top of young plant, one from 7-foot plant one foot from ground, and one from 3-foot plant 18 in. from ground.

## Chemical Analysis

|                            | Green |       | Air Dry |       |
|----------------------------|-------|-------|---------|-------|
|                            | 6512  | 7598  | 6512    | 7598  |
| Sample No.....             |       |       |         |       |
| Spines.....                | .45   | .67   | 4.48    | 6.98  |
| Water.....                 | 92.96 | 91.14 | 8.84    | 7.60  |
| Ash.....                   | .91   | 1.25  | 11.75   | 12.97 |
| Crude Protein.....         | 1.07  | .81   | 13.91   | 8.43  |
| Crude Fat.....             | .18   | .20   | 2.28    | 2.11  |
| Nitrogen Free Extract..... | 3.60  | 5.13  | 46.64   | 53.50 |
| Crude Fiber.....           | 1.28  | 1.47  | 16.58   | 15.30 |
| Organic Matter.....        | 6.13  | 7.61  | 79.41   | 79.34 |

## COMPILATION OF ANALYSES.

The following pages contain a compilation of all the chemical analyses found in this bulletin, together with such other data as will be found necessary in making a rapid study and comparison of the information presented. In the seventh column headed "Formula and Remarks" is given the formula of the specimens analyzed. For an explanation of this formula see page 7.

SOME LITERATURE DEALING WITH THE CHEMISTRY  
OF THE CACTI.

Adriance, Duncan, Tilson, P. S. & Harrington, H. H.

Texas Agric. Exp. Station Bull. 35: 604. 1895. Analyses are given of stem and fruit and comparisons made. Statements made that animals eat the fruit readily and that deer and hogs do well on it.

Anonymous.

Texas Agric. Exp. Station Annual Rep. No. 6: 377. 1893. Pear is said to cause bloat.

Bourde, Paul.

La Revue Tunisienne, organe de L'Institut de Carthage. Tunis, 1894. Translation by J. H. Maiden in Agric. Gaz. N. S. W. 7: 651. 1896.

DeGraffe, Bertha L.

Am. Jour. Pharm. 68: 169-177, Pl. 1896. *Opuntia vulgaris*. Chemistry and discussion of history, etc.

Ewell, E. E.

The Chemistry of the Cactaceae. Jour. Am. Chem. Soc. 18: July 7, 1896. A study of the alkaloids of species of *Anhalonium*.

Forbes, R. H.

Ariz. Agric. Exp. Station 15th Ann. Rep. 496, 1904. Analyses are given of *O. fulgida* joints and fruit, *O. spinosior* stems and fruit, *O. Engelmanni* stems and *O.* ("Spinless Sicilian") stems.

Goss, Arthur.

N. Mex. Agric. Exp. Station Bull. 17: 36, 1896. Chemical analyses of *O. camanchica* are given. In Bull. 18: Prof. E. O. Wooton discusses briefly the sample used in the analyses.

N. Mex. Agric. Exp. Station Bull. 44: 4, 1903. Analyses are given of *Opuntia camanchica*, *O. macrocentra* and *O. arborescens*.

Guthrie, B. F.

Agric. Gaz. N. S. W. 11: 671, 1900. Analyses of *O. ficus-indica*, *O. elatior*, *O. brasiliensis*, *O. coccinellifera* are given. Comparisons are made with Wolff's analyses of fruits and conclusion drawn that fruit is of less value as forage than the joints because they contain less nutritious substance and more fiber.

Harrington, H. H.

Texas Agric. Exp. Station Annual Rep. No. 1: 28, 1888. Analyses are given and comparisons are made with carrots and turnips analyzed by Mass. Exp. Station in 1887. Considered an economic thing.

Jaffa, M. E.

Cal. Agric. Exp. Station Rep. 22: 49, 1904. Analyses of "Cactus Plant" is given. This is probably an *Opuntia*.

Juritz, Chas. F.

Rep. Senior Analyst Cape of Good Hope for 1898, p. 63, 1899. Analyses made of different portions of the plant and conclusions drawn that portions neither too old nor too young are most valuable as stock feed

Lima, Dr. Gaetano Mancuao.

Le Stazioni Sperimentale Agraric. Ital. (Rep Ital. Exp. Station Modena, Italy 28: 805, 1895.) The most comprehensive analyses of fruit and stems of *O. ficus-indica* we have seen.

Maiden, J. H.

Agric. Gaz. N. S. W. 7: 651, 1896. Trans. of Bourde's article in La Revue Tunisienne in 1894. Considerable chemical data given. Plan for studying pear outlined.



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## ERRATA.

Page 22, table No. IV, insert comma “,” after “Cane Cacti” on first line and “Prickly Pears” on third line.

Between pages 32 and 33—Plate IV, change “leuotricha” to “leuco-tricha,” and “P. D. C.” to P. DC.”

Page 37—Line 5, second word read *Engelmannii*.

Page 42—Line 19, second word first letter change “O” to “o.”

Page 65—Line 9, between second and third word insert “Lem.”

Page 70—Line 17, second word read “TAPON.”

Page 75—Line 3, third word read “BLANCO.”

Page 82—Line 2, third word read “basilaris.”

Page 87—Line 16, between fourth and fifth word insert “I.”

Page 92—Line 3, third word read “Engelm.”

Page 105—Line 3, second word change “A” to “a.”

Page 107—Line 3, second word change “L” to “l.”

Page 107—Line 3, third word change “c” to “C.”

In tables of ash analysis change “Sios” to “SiO<sub>3</sub>” on pages 34, 37, 41, 46, 57, 58, 65, 67, 75, 80, 84, 89, 90, and 96.

Omit all periods “.” placed in sample numbers.

Page 34—Analyses of the Ash, No. 7515 under iron read 20.

Page 44—Under Chemical Analyses No. 7429 crude fiber, change 1.14 to 1.19.

Page 45—Chemical Analyses No. 7596, water, change 97.76 to 87.76.

Page 52—Analyses of the Ash, No. 7784 read Iron .15.

Page 53—Chemical Analyses change sample No. 7750 to 7759.

Page 53— “ “ change sample No. 7709 to 7009.

Page 55— “ “ No. 3101, spines, insert 17.95.

Page 95— “ “ No. 6252, ash, change 17.30 to 13.30.

Page 106— “ “ No. 7785, ash, change 11.55 to 14.65.

Page 106— “ “ No. 7785, crude protein, change 12.35 to 12.05.

Page 111— “ “ No. 7628, organic matter, change 24.84 to 23.84.

Page 112— “ “ No. 7630, crude protein, change 8.07 to 3.07.

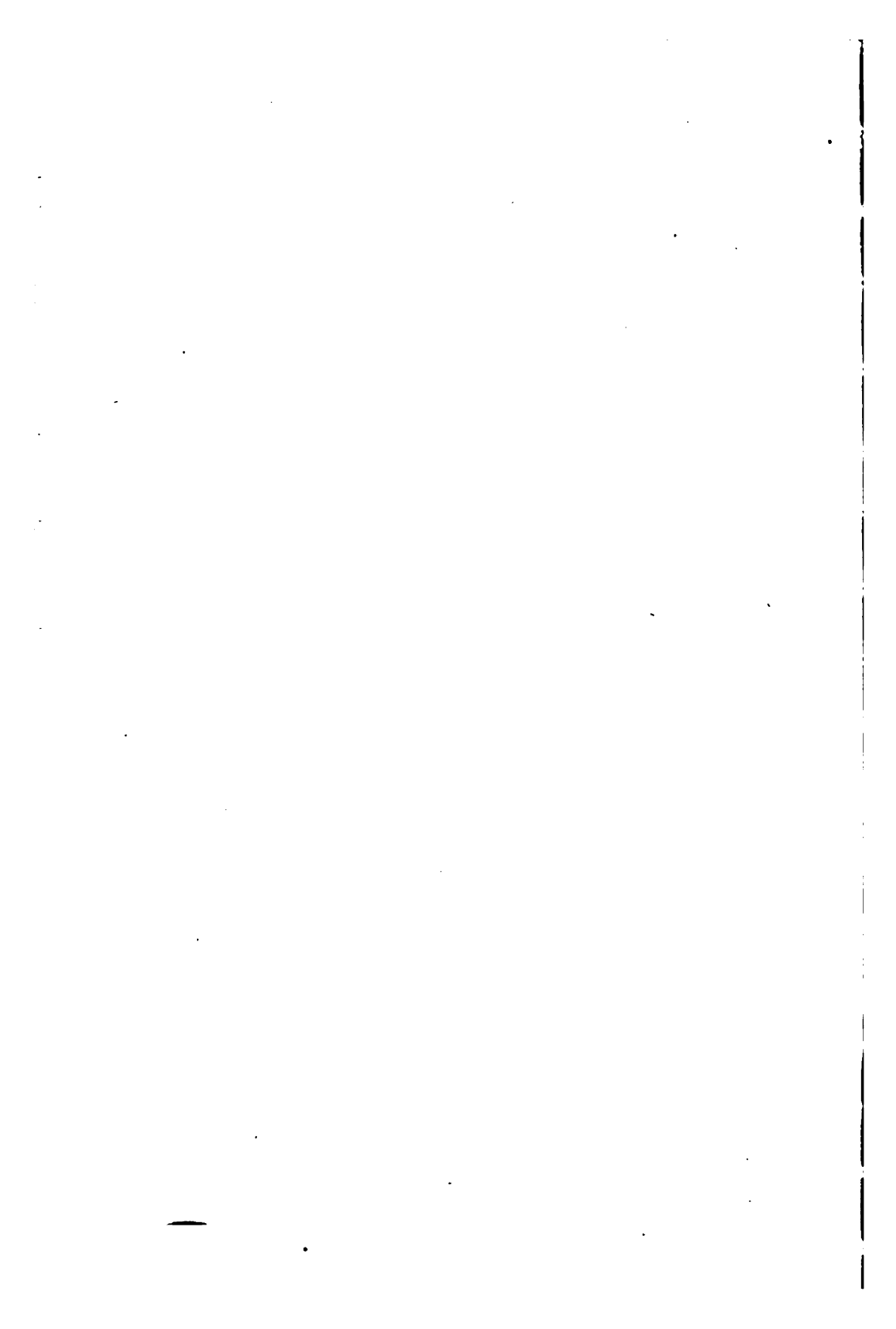
“ “ “ “ No. 7631<sup>1</sup> Nitrogen free extract, change 9.07 to 8.07.

NOTE:—In the list of some literature dealing with the Chemistry of Cacti on p. 124, thru an oversight no note was made of the work reported by E. F. Ladd, in the 6th Annual Report of the New York Experiment Station p. 419.



No.

6329 No  
7571  
6330  
7572  
6542  
7515 No  
7567  
7516  
6243 No  
7787  
7011  
6240 No  
7774  
6692  
7890  
6247 No  
7790  
3002  
3073a  
3073b  
6248 No  
7791  
6544 No  
7854  
6567 No  
7-63  
6573 No  
7876  
6535 No  
7596  
6534  
7429 No





No.

|       |         |
|-------|---------|
| 3032  | Nopal E |
| 6578  | "       |
| 7809  | "       |
| 6579  | "       |
| 7812  | "       |
| 7475  | Cacana  |
| 7476  | "       |
| 6242  | Nopal E |
| 7784  | "       |
| 3025  | "       |
| 3067  | "       |
| 8022a | "       |
| 8022b | "       |
| 7009  | Nopal E |
| 7759  | "       |
| 7010  | "       |
| 3069  | Nopal E |
| 3018  | Nopal E |
| 3100  | "       |
| 3101  | "       |
| 3016  | "       |
| 3000  | Nopal E |
| 3066  | "       |
| 6344  | "       |
| 7568  | "       |
| 6543  | "       |
| 7639  | Nopal E |
| 6580  | Prickly |
| 7813  | "       |
| 6691  | Nopal E |
| 7889  | "       |
| 6241  | Nopal E |



| No. |  |
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|      |          |
|------|----------|
| 7782 | Nopal E  |
| 7591 | Nopal C  |
| 7635 | Nopal j  |
| 7715 | Nopal... |
| 6530 | Nopal t  |
| 7590 | "        |
| 6529 | "        |
| 6531 | "        |
| 7633 | Nopal t  |
| 6575 | Mission  |
| 7810 | "        |
| 6562 | "        |
| 7841 | "        |
| 7519 | Nopal de |
| 7377 | "        |
| 7733 | Nopal ch |
| 7518 | Nopal di |
| 7593 | Nopal je |
| 7594 | "        |
| 7621 | Nopal vi |
| 7623 | "        |
| 7840 | Nopal Pr |
| 6525 | "        |
| 6690 | Nopal Pr |
| 7888 | "        |
| 6675 | Nopal Pr |
| 7734 | Nopal Pr |
| 6576 | Nopal Pr |
| 7811 | "        |
| 6577 | "        |

Average  
\* This se

For ex



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| No. |
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|       |        |
|-------|--------|
| 6254  | Cholla |
| 6255  | "      |
| 7802  | "      |
| 7796  | "      |
| 6258  | "      |
| 7801  | "      |
| 8170a | "      |
| 8170b | "      |
| 6256  | Cholla |
| 7800  | "      |
| 6249  | "      |
| 7796  | "      |
| 6250  | "      |
| 7799  | ?      |
| 6245  | .....  |
| 7806  | .....  |
| 6246  | .....  |
| 7778  | .....  |
| 8162a | .....  |
| 8162b | ?      |
| 6251  | "      |
| 7793  | "      |
| 6252  | "      |
| 7797  | Cane d |
| 7715  | Cande  |
| 3019  |        |
| 3070a |        |
| 3070b |        |
| 3071  |        |
| 0527  | Gocou  |
| 7695  |        |
| 0523  |        |
| 6540  |        |



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| No. |  |
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|       |            |
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| 6565  | Goconoz    |
| 7862  | "          |
| 6566  | "          |
| 7858  | "          |
| 6608  | "          |
| 7887  | "          |
| 6606  | "          |
| 7893  | "          |
| 3008  | "          |
| 6698  | "          |
| 7894  | "          |
| 3009  | "          |
| 78b0b | "          |
| 7899  | "          |
| 7850a | "          |
| 7900  | "          |
| 6244  | "          |
| 7785  | "          |
| 7786  | "          |
| 6328  | Tasajilla. |
| 7749  | "          |
| 7474a | "          |
| 7474b | "          |
| 7508  | Tasajilla. |
| 7628  | Tasajilla. |
| 7629  | "          |
| 7630  | "          |
| 7631  | "          |
| 7601  | Clavelina. |
| 7649  | "          |
| 3022  | "          |
| 3026  | "          |

Avera





|     |  |
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|       |          |
|-------|----------|
| 3008  | Viznaga  |
| 3072  | "        |
| 8173a | "        |
| 8173b | "        |
| 6331  | Pitalla  |
| 7748  | "        |
| 6526  | Pitalla  |
| 7644  | "        |
| 6607  | Pitalla  |
| 7896  | "        |
| 7807  | Pitalla  |
| 6699  | Giant ea |
| 7805  | "        |
| 6561  | "        |
| 6518  | Garramb  |
| 7632  | "        |
| 6512  | Organo   |
| 7598  | "        |

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## **BULLETIN NO. 61**

JANUARY, 1907

**New Mexico College of Agriculture and Mechanic Arts**

**AGRICULTURAL EXPERIMENT STATION**

**AGRICULTURAL COLLEGE, N. M.**



**Wheat Grown by Dry Farming at Las Vegas**

# **DRY FARMING IN NEW MEXICO**

BY

**J. J. VERNON**

SANTA FE, N. M.:

THE NEW MEXICAN PRINTING COMPANY

1907

# NEW MEXICO AGRICULTURAL EXPERIMENT STATION

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## SUMMARY

1. The term "Dry Farming" is a misnomer, but its meaning is now well understood and its use is now almost universal.

2. "Dry Farming" practices include the following:

a. Deep plowing before the rainy season sets in, in order to provide in the soil a capacious water storage reservoir and an ample space for root development.

b. Light, deep even seeding or planting in a well prepared moist soil.

c. Frequent, thorough, level cultivation before as well as after sowing or planting.

d. The use of seed bred and selected for the conditions prevailing.

e. The use of machinery of large capacity.

f. The adoption of methods for the concentration of crops.

3. Fall seeding of cereals is preferable to spring seeding wherever the conditions will permit for the following reasons:

a. The work is distributed over a longer period.

b. The root system of the crop becomes well developed so that spring growth is more rapid.

c. The growth above the surface of the ground, though sometimes small, serves a valuable purpose by modifying the windsweep at a time when its effects are most marked, thus preventing, in a measure at least, the blowing of the soil from around the roots of the plants, and, at the same time, holding the snow fall upon the ground until it melts.

d. The crop covers the ground earlier in the spring, thus reducing the loss of moisture through surface evaporation.

e. The crop usually ripens earlier, a feature that is important for two reasons: First, the work of preparing the ground for the next crop can be begun earlier, and second, the crop may escape frost more frequently in sections having short seasons.

4. It is important to retain the snow upon the land, especially in sections where it forms a large part of the total precipitation. The snow fall may be retained in several ways: First, by leaving the ground rough when the plowing is done late in the fall; second, by throwing up borders across the field at right angles with the prevailing winds as winter approaches; and, third, by planting hedge rows or shrubbery across the field at short intervals. The last named method is preferable wherever possible.

5. Usually less seed should be planted per acre under dry farming conditions than is used in humid sections. The less the precipitation the smaller should be the amount of seed planted.

6. The yields in dry farming belts may be and sometimes are very large, but it is not best to expect as large yields in dry farming belts as are secured in humid sections, unless the cultural methods are very much superior.

## INTRODUCTION

The term "Dry Farming" is a misnomer since crops cannot be grown without water. The meaning of the term as popularly used is the practice of farming with less than a normal amount of water. The expression "Campbell System" is much used because Mr. W. H. Campbell, who was one of the first to study the question, was so eminently successful in demonstrating that by deep plowing, adequate cultivation and careful attention to details, crops could be grown with considerably less rain or snow fall than had been, in former years, thought possible. "Scientific Farming" has been proposed, but since all farming should be based upon scientific practice, it will, probably, never become generally used. The term "Dry Farming" is now well established and quite well understood, and will very likely prevail for some time to come. In the earlier operations of agriculture in this as well as other countries the most fertile areas were the first to be brought under cultivation. This was often determined by the vegetation already growing upon the land in a wild state. Since it is well known that the right amount of water properly distributed throughout the growing season in a very large measure determines the productiveness of a soil, hence those areas over which the rainfall was abundant and well distributed were occupied and cultivated first. As the population increased those areas less favorably situated and not so well watered were occupied. The seeking for new areas has gone on until the lands where the rainfall, which, heretofore, has been considered too scanty for the production of paying crops and only fit for range purposes, are now being brought under cultivation. Coincident with the bringing in of less valuable areas, the work of the Agricultural Experiment Stations and of the educated and thoughtful farmers have wrought wonders in the amelioration of farm practices. Inventive ingenuity has supplied improved machinery with which many operations

are rendered practical that were heretofore either impossible or impracticable. With the new methods of handling soils and with the advance in the knowledge of methods, crops are now successfully grown on what are termed dry farming areas.

With the same methods and machinery these lands could have been cultivated with the same degree of success many, many years ago had there been the necessity. However, it must be remembered that there is a limit even at the present time to which we can go, although the investigations of future years may disclose methods whereby the present limits may be far surpassed.

There are three general groups into which the agricultural lands of the Territory, so far as dry farming is concerned, may be placed: First, sections where crops can be grown annually; second, areas where crops can be grown only biennially; and third, lands where the rain and snow fall is insufficient for regular crop production. Such grouping will not hold good throughout a long series of years for it may and no doubt will happen that during a series of dry years, in sections where crops have been grown annually, crops can be produced only biennially.

Attention should be called to the fact that the rainfall of certain sections is due, partially at least, to the high altitude, and here the seasons are short, while other dry farming sections owe their relatively large rainfall to their proximity to the humid regions.

### **Forms of Soil Moisture**

Soils may contain water in three forms:

**Free Water.**—Free water occupies the larger spaces between the soil particles. It may pass through the soil or stand in it, but when in motion its movements are always downward and never upward, for the reason that it is controlled by the force of gravity. Free water may and often does move in a lateral direction, but at the same time it is also moving downward. Our wells are replenished with free

water and when sufficiently near the surface of the soil it may form a valuable supply of water for crops. Though field crops cannot make use of free water directly, they can indirectly, since free water may and often does form a supply for capillary water. One must not get the idea that free water will take the place of rainfall or irrigation.

**Capillary Water.**—Capillary water is a rather thin film of moisture which surrounds and is held close to the soil particles by adhesion. In other words, capillary water may be said to be that portion of the free water upon which the force of adhesion of the soil particles is greater than the force of gravity. Capillary water may move through the soil in any direction and its movements are always towards the spot where there is a less amount of moisture. If the soil is dryer below than above, capillary movement will be downward; if it is dryer above than below, capillary movement will be upward; and if the soil is dryer at either side of a certain spot, capillary movement remedies the defect by moving in a lateral direction. The movement of water by capillary force is nicely illustrated by touching the small tip of a sponge to a water surface. The water rises rapidly into the sponge and climbs upward to the topmost part and laterally to the most remote corner. Furthermore, if water be very slowly dropped upon the top of a sponge it will soon find its way to the lowest point, distributing itself equally in all parts. The movement of oil up through the small spaces between the threads of a lamp wick also illustrates capillary movement. Thus we see that the capillary movement tends to equalize the moisture content of the soil; a very important factor in crop production for the reason that when the moisture in the upper layers of the soil, which contains the plant roots, is exhausted either by evaporation from the surface of the soil or passed out through the growing crops, it is continuously replaced from the water stored in the soil below until that too becomes exhausted. Capillary water is the chief source of the supply of moisture to crops. It is by far the most important form of soil moisture, and

therefore, the one we must study and learn the most about if dry farming operations are to be made successful.

**Hygroscopic Water.**—Hygroscopic and capillary moisture are similar. They differ in the thickness of the film which surrounds the soil grain, and also in their movements. Hygroscopic water does not move from one soil grain to another like capillary moisture. It may be said to be an exceedingly thin film of moisture which is so firmly held to the soil grain that it cannot be drawn away by the force of capillarity. This form of moisture is not important from the standpoint of crop production for plants cannot depend upon it for their growth, and yet it has value. For example, if the hygroscopic moisture is low in a soil it will require more moisture to start capillary movement than if there were a maximum amount of hygroscopic moisture, and therefore, just so much more moisture will be required before the growing crop can be supplied.

#### **Translocation of Soil Moisture**

Soil moisture by proper handling may be moved from one layer of soil to another. By loosening the lower layers of the soil the tendency of the water will be downward during the rainy season, but should the farmer desire to bring a portion of that moisture quickly to the surface in order, for example, to cause the speedy germination of the seed he can do so by packing the surface soil. The upward movement may be checked by again forming a loose surface.

Translocation of soil moisture, however, takes place sometimes without the assistance of the farmer. For instance, if the first foot of surface soil has become rather dry, this dry surface tends to act as an additional mulch, but let there be a light shower, only sufficient to slightly moisten the dry surface foot, there will at once be set up a more rapid transfer of the moisture from the deeper layers of the soil into the recently moistened foot. Professor F. H. King, in his book on "The Soil" recites an experiment in which the first four feet of soil under much the same conditions as described

above gained from lower soil layers by translocation 45½ tons of water per acre.

This statement strongly impresses the importance of the deep storage of water so that it may later form a valuable source of supply at a critical period in the growth of the crop.

### **Storing Water in the Soil**

Reservoirs are provided for the storage of water on the surface of the ground. Such water is held until a time when it is needed for crop production or for other uses. The storage of water in the soil contemplates precisely the same results. The soil water is to be stored and held until the time arrives when the stored moisture can be used by the growing crop.

As with the surface storage of water, if soil moisture is to be stored, there must be a storage reservoir. Space must be provided for the water in the soil itself. It is evident, therefore, that in order to provide storage room in the soil the particles of which the soil is composed must be separated so as to leave spaces for the water between them and the greater the depth to which this loosening is carried the greater will be the storage capacity. It matters very little how the separation of the particles is accomplished, provided it is done thoroughly. Either a disc plow or a common mold-board plow is most commonly used. The subsoil plow follows the stirring plow wherever the soil is to be loosened to a greater depth than is possible with the stirring plow. Deep plowing then is the first requisite to the formation of a capacious water reservoir and only with a large reservoir in the soil can we hope to store an abundance of water for future use.

Provided with ample storage facility the rain which falls upon the surface immediately sinks into the soil through the openings which have been provided, and it naturally follows that there is no longer any surface run off. In dry farming sections the rains are torrential in character and therefore

it is especially necessary to have a deep soil reservoir which will absorb this comparatively large amount of rain falling in a short time.

### **Conserving Soil Moisture**

Soil moisture is lost either by the free water percolating downward until it reaches the ground water table and passes into ditches, or streams, or by returning by capillary action to the surface of the ground where evaporation takes place and it passes off into the atmosphere. Since for our present discussion we are dealing with conditions where the rainfall is not large it is improbable that any considerable amount of water, if any at all, is lost by downward percolation, and therefore, the loss in that direction may be entirely ignored.

As soon as the surface layer of the soil becomes dryer than that portion lying immediately below it, the moisture from below moves toward the surface to replace that removed by evaporation. It is evident, then, that if we are able to check this upward movement of the moisture, and therefore, check the surface evaporation, we have reached a most important result. This we are able to do, not completely stopping all upward movement of the moisture from below, but so materially checking that movement and thus lessening the amount of moisture which reaches the surface of the soil and which is sure to be evaporated as soon as it comes in contact with the air, that it forms one of the most important aids to crop production under practically all conditions of agricultural operation. The checking of the loss of moisture from the surface of the soil is important throughout the rain belts, but it is vital to success in the semi-arid belts wherever crop production is attempted. In the latter sections the total rainfall is so small that if any considerable quantity be lost by surface evaporation there does not remain sufficient moisture in the soil for the growth of crops.

The principal means employed in the conservation of moisture are first, loosening the soil to great depths so that the water can penetrate deeply into the soil; second, adding

humus to the soil either by applying manure directly or by plowing under all stubble and other litter; and third, surface cultivation. While the first and second means are important and should never be neglected, yet the third, that of surface culture, must necessarily remain the most important method for checking the loss of soil moisture from the surface.

It may be proven by simple means, that the rapidity of the movement of water by capillary action is dependent upon the character and size of the spaces between the soil particles. The spaces are more or less irregular and are by no means uniform in size. They may form tubes which are irregular or almost if not quite round, or they may form thin sheet-like openings. The smaller the openings, whether tubes or otherwise, the more powerful will be the capillary action. This may be proven in the following way: Purchase from the druggist three glass tubes of different sizes. Let the smallest have an opening through it no larger than a pin, and the largest an opening, say, one-fourth inch in diameter. Place all of these tubes in a vertical position in a glass or bowl one-half full of water and note the distance from the surface of the water in the glass to the top of the water within each tube. The greatest distance will be noted within the smallest tube and the same would be true if the tubes were crooked, thus proving that the capillary movement is strongest within the small tubes in the soil. From this we may conclude that if the particles of the surface soil have, by rain or by rolling, been pressed closely together, the tortuous tubes between the particles are reduced in size, thus obtaining the maximum capillary effect, and so the amount of soil moisture coming to the surface and being evaporated into the atmosphere is increased. Furthermore, to check this loss of moisture we must again enlarge the openings between the particles in the surface soil. In other words, we must enlarge the capillary tubes for we have learned that the moisture rises less freely through the large openings. This is most quickly and cheaply accomplished by repeated cultivations, thus forming what is known as a "dust mulch" upon



the surface. Next to the storage of moisture in the soil the conservation of soil moisture by surface cultivation is most important to dry farming operations.

### Windbreaks

The windsweep is considerable during certain seasons of the year in many sections where dry farming has been or will be practiced. The moisture that is evaporated from the surface of the ground is carried away more and more rapidly as the velocity of the wind increases. Therefore anything that tends to check the windsweep, decreases its desiccating power. Grass two or three inches high has a noticeable effect upon the windsweep on the surface of the ground for some distance. A hedge row or a row or two of shrubbery produces marked effects upon the velocity of the wind and indirectly upon the amount of moisture carried away from the soil surface. The writer has been informed that in certain parts of Manitoba, Canada, the wind in spring is so strong as to literally blow the surface soil away from around the roots of wheat plants, thus destroying them. The principal preventive measure used is the planting of miles upon miles of the shrub wormwood (*Artemisia absythifolia*).

This shrub sends up so many stems from the crown as to form a very thick and compact foliage, making an excellent windbreak. A row is planted every twenty to forty rods through the field of grain. The wind is only checked near the ground but that is all that is necessary in order to protect the young plants until they have become sufficiently established to protect the ground.

The shrub *Artemisia* grows luxuriantly in the irrigated valley of the Rio Grande and since a number of species of the genus are found growing upon our plains, *Artemisia tridentata* in the northern portion and *Artemisia filifolia* in the southern portion, (the common sage brushes), I presume that it may, with proper care and cultivation, grow under such conditions as field crops can be profitably grown.

### **Retaining the Snow Fall**

It is quite as important to conserve the snow fall as the rain fall. Snow may even form the larger portion of the total precipitation in certain sections. A capacious water reservoir formed as described heretofore by deep plowing will take care of all melting snow since the water formed therefrom will immediately sink into the soil. But the snow carried away by the wind is lost.

To prevent this loss several methods have been suggested, but they are all based upon one object, that of stopping or modifying the windsweep. Since checking the windsweep is eminently desirable in order to prevent soil desiccation during the growing season, it naturally follows that any effort in that direction will assist in retaining the snow in place, until it is melted by the warm spring weather.

Leaving the surface of the soil rough after plowing will in a measure retain the snow, but, unless the plowing is done late in the fall so that there will be little loss of moisture from the exposed surface, more harm will be done than good, except where there is little or no rain fall. If, however, the land has been plowed early and the surface mulch immediately formed in the usual manner, ridges may be formed with a stirring plow or "middle buster." Of course the ridges must be made at right angles with the prevailing winds. These ridges will tend to check the windsweep and the snow will be deposited and held in the furrows until it melts. In the spring, as soon as the soil is sufficiently dry to be cultivated without "pudding," these ridges should be leveled off and a surface dust mulch established. Otherwise large quantities of soil moisture will be evaporated from the exposed surface of the ridges.

Better than leaving the surface of the field rough after plowing, or throwing up ridges late in the fall to be again torn down in the spring at a considerable expense in labor, is the method of providing permanent windbreaks at frequent intervals, provided, however, that such windbreaks are possible.

### **Quantity of Water Required by Crops**

That portion of the plant food which comes from the soil passes into the plant dissolved in the soil water. The water in which this food is carried in solution is disposed of by the plant in two principal ways,—it either uses it for assisting in building up its own tissues or throws it off through small openings in the leaves and young growth. In fact, most of the water taken into the plant through its roots, passes upward and out again into the air leaving within the plant the dissolved food it contained when it entered. The soil water, then, is the vehicle nature has provided by means of which the food of the soil is carried into the plant. Large quantities of water must pass through the plant in order to deposit sufficient food therein to bring it to maturity.

The amount of water required for the growth of crops will depend among other things, upon the kind of crop and the atmospheric conditions. Some crops require very much more water than others, not only because they require a much longer time in which to grow but also because they demand more water in order to complete their growth.

Experiments seem to show that more soil water is required to grow crops in the semi-arid belt than in the humid sections. Professor F. H. King on page 139 of his book entitled "Physics of Agriculture", says: "It has been determined by careful and extended observations in this country and in Europe that almost any one of the cultivated crops withdraws from 300 to 500 tons of water from the soil for each ton of dry matter produced."

Professors Widdsoe and Merrill, in Bulletin No. 91 of the Utah Agricultural Experiment Station, pages 80, 83 and 84 say: "In Europe and the Eastern States, it has been found that to produce one pound of dry plant substance requires nearly 500 pounds of water. That is, one ton of absolutely dry lucern hay grown in a humid climate, is produced at an expense of about 500 tons of water."

"In the drier climate of Utah, more water is ordinarily required to produce one pound of dry matter. Experiments

on this subject, not yet published, indicate that on the arid farms about 750 pounds of water are required to produce one pound of dry plant substance."

"The chief arid farm crop is wheat. Grown without irrigation, nearly one-half of the wheat plant consists of the seeds or wheat kernels. Knowing that about 750 pounds of water are required to produce one pound of dry matter, it may be calculated that it will require 50 tons of water to produce one bushel of arid farm grain."

"This seems a very large amount of water, yet, when compared with the amount of water that falls upon our soils in the form of snow or rain it is very small. For instance, a rainfall of one inch amounts to over 118 tons per acre, or more than enough if it could be used by the plant to produce two bushels of grain. Twelve inches of rainfall amounts to 1361 tons of water per acre, or enough to produce 27 bushels of grain.\*\*\*"

"If only half is kept in the soil there is a possibility of more than 13 bushels per acre, which is a very profitable yield. By the employment of proper methods of tillage, 10 inches or considerably less may be so conserved in the soil as to yield good crops. Where the rainfall is light, the land should be allowed to rest at least every other year, so that the precipitation of at least two years might be stored in the soil for the benefit of the next crop.\*\*\*"

Since New Mexico is located a little south of Utah we may expect that, other things being equal, somewhat more water will be required to grow the same kind of crops in the former than in the latter.

The discussion of the quantity of water required by plants at once impresses one with the extreme importance of conserving the soil moisture. If there were no losses of soil moisture other than through the plant itself, profitable crops could be grown over a very large portion of New Mexico. But in fact, the most constant effort is required to prevent the surface evaporation whereby a large portion of the rain-

fall is dissipated without doing a particle of good to the growing crop.

Those crops that require the least amount of water to bring them to maturity or that occupy the ground a short period of time, of course, are best suited to semi-arid conditions, or may be most quickly developed into strictly dry farming crops.

### **Systems of Dry Farming**

For convenience dry farming may be divided into three main systems: 1. Crops annually,—a system whereby a crop, whether heavy or light, is grown every year. Probably crops may be grown every year with say 18 inches of rainfall, provided the proper methods are followed and the rainfall is properly distributed for storage and cropping. 2. Crops biennially,—a system under which crops are grown only every other year. In Utah yields of 30 bushels of wheat per acre have been obtained every other year with an annual rainfall of 12 inches and good crops biennially have been reported with an annual precipitation of only 8 inches. The soil was of an excellent character and the methods employed were up-to-date. 3. A modification or combination of the first and second. Under this class may be mentioned the production of two crops in three years, three crops in five years, or two crops in one year, one being a catch or cover crop, sown for its effect upon the soil or the soil moisture, to be plowed under before the regular crop is sown.

The system chosen for any section must necessarily depend upon a number of conditions, among which may be mentioned: The rainfall; the distribution of the rainfall; the length of the growing season; the general climatic conditions, such as the humidity of the atmosphere, the number of cloudy and clear days, the day and night temperature, and the windsweep; the elevation; the general aspect of the country and the farm; the character of the soil and subsoil; the depth of the soil and subsoil; the machinery available; and last but not least, the means for the disposal of the products.

### **Dry Farming Crops**

There is quite as large a range for adaptation, amelioration and breeding with dry farming crops as with those grown under humid conditions. The necessity for such effort is far more urgent, and the reward quite as promising.

Crops must be selected or developed that will fit the environments, and there seems to be quite as large a field for investigation in the improvement and development of crops suited to the various conditions in the dry farming sections as in the improvement of methods of handling the soil. In other words the pedigree of the seed is quite as important as the cultural methods. Neither should be neglected. Certain machines are designed for certain kinds of work. Certain breeds of animals are selected for special results. No one would think of trying to harvest wheat with a threshing machine. No one would for a moment think of placing a thoroughbred Hereford cow in the city dairy. So we must select kinds and classes of seeds for our particular purposes. If the rainy season is short, early maturing crops must be selected, those having a short period of growth. If the rainy season is preceded by a rather long period when the moisture content of the soil is rather low in spite of the means employed to increase it, then crops should be chosen that will make the necessary early growth with a minimum amount of moisture and later be pushed forward to rapid maturity when the rainy season sets in. Still other crops or strains of seed must be selected wherever the moisture content of the soil is ample throughout the growing season. Under such a condition it would be quite useless to grow crops bred for and adapted to a very short season's growth. The dry farmer must not neglect the cultural methods, but he must not be tied to the idea that the way in which the soil is handled is the only essential. The kind of crop and the class or strain of seed used are factors which ultimately will have much to do with the result.

It has been demonstrated by repeated experiments that

crops can within certain limits be adapted to new and different environments. Aquatic plants in time have adapted themselves to and become dry land plants. So to, plants that for centuries have grown in conditions of abundance of moisture, have gradually become adapted to conditions where there was very decidedly less moisture. This very wise provision of nature supplies the means whereby man is able to transport and adapt crops to new and heretofore untried conditions. He is only barred in his progress by the limitations nature has set.

There is little doubt but that strains of seed of certain crops which have been successfully grown for years under trying semi-arid conditions will be in great demand. As a result of this demand we may reasonably expect pedigreed dry farm crops to appear and they will fill an important want.

To give a list of crops suited to dry farming for all sections and conditions is practically impossible. Crops that are well suited to a certain class of conditions would be wholly unsuited to another. Therefore, the following brief list must be considered only as suggestive :

1. Cereals.—Wheat stands at the head among the cereal crops for dry farming areas and it probably stands at the head of all crops for this purpose when everything is considered,—adaptability to dry farming conditions, cost of production, profits, etc. There are certain classes of wheats that do best under drouthy conditions. The durum or macaroni wheats seem to do exceedingly well when compared with other classes, yet there are varieties among other classes which also do well on dry farms. Spelt, oats, rye and barley are all used on occasion. Barley is probably the poorest crop mentioned because it is comparatively a shallow rooted crop and for this reason, likely to prove less valuable than a crop which forages more deeply for its food. For methods of seeding see "Fall Seeding of Cereals."

2. Sorghums.—Both saccharine and non-saccharine sorghums are grown. Fodder cane, kaffir corn, Jerusalem corn

and doura belong in this class. They should be sown for hay with a hoe drill or planted with a corn planter and cultivated. The sorghums may also be double rowed, i. e., planted in groups of two rows about eight inches apart and cultivated.

3. Millets.—Among the millets are found some of the most paying dry farm crops. Some of them grow and mature with a remarkably small amount of moisture present in the soil and at the same time the period of growth is very short.

4. Legumes.—There are a few legumes that have shown value as dry farm crops. Peas, beans and alfalfa are the most promising although in order to secure a stand of alfalfa it will very probably require summer fallowing one year in order to accumulate sufficient moisture to insure perfect germination. After a stand is secured alfalfa has given good results in some sections. The alfalfa should be sown with the hoe drill and rather deeply for such small seed.

5. Vegetables.—Garden vegetables form an important group. They add so greatly to a bounteous table supply. Many vegetables grow to the proper stage for consumption in a few weeks, and therefore, are surer than almost any other class of crops. If markets are available they may be made a source of considerable revenue.

6. Trees.—Both fruit and shade trees are grown in districts where dry farming is practiced. The home surroundings may be made more comfortable and greatly improved in appearance by the free use of shrubs and trees. The same care, however, must be exercised in the selection of the kinds to plant and in their care as is used with field crops. The first two or three years, until they become deeply rooted, is the most critical period in the life of a tree or ornamental shrub. Cultivation during that period should be constant and thorough.

There are no doubt many other crops not mentioned that have proven or will prove their value for dry farming purposes.



### Plowing

Plowing is the most important factor connected with dry farming operations. If the plowing is not properly done an adequate water reservoir will not be formed in which to store the rain or snow fall. Should this feature of the work be neglected much of the rain and melting snow will run off from the surface of the ground and be lost instead of sinking into the soil, there to be stored.

Plowing, if possible, should be performed when the soil is fairly moist, so that it will come up mellow and can easily be leveled and fined. Discing immediately after the crop is removed will aid materially in this respect.

The character of the soil and the season of the year will largely determine the depth to which it is best to plow. Usually the plowing should be from 8 to 12 or more inches deep if done in the fall, obviously somewhat shallower if done in the spring.

The subsoil plow may follow the plow if after due trial upon small areas it proves beneficial upon that particular soil and subsoil and under the conditions prevailing. The plow should be followed by the sub-surface packer, especially if the plowing has been very deep. If a sub-surface packer is not available the field should be run over with the disc set straight but well weighted down. The sub-surface packer should be followed by the acme harrow or toothed harrow, thus thoroughly pulverizing and fineing the surface so as to form a good mulch and at the same time provide against any surface run off of the water that subsequently falls.

The sub-surface packing and the formation of a surface mulch should be performed each half day. If the soil is left loose and a large surface exposed to the air for only a few hours, large quantities of moisture will be evaporated, pass off into the atmosphere and be lost to the crop. Success often lies in the proper performance at the right time of these seemingly insignificant operations.

### **Cultivation**

The character of the cultivation practiced in the semi-arid belt should be such as to put the soil in the best possible condition for plant growth and at the same time conserve the greatest possible amount of soil moisture.

Experiments, often repeated, have proven that the evaporation of moisture from a soil surface is least when that surface is least exposed to the air. It follows, therefore, that any irregularities in the surface increases the surface exposure, which in turn increases the evaporation of moisture. The reason for laying so much stress upon following the plow immediately with the harrow is to prevent the loss of moisture from the irregular surface. Level culture with a fine even surface has proven the best method for conserving moisture and for most crops this condition is the most favorable for root development and expansion. There may be conditions of a peculiar nature where this rule will not hold good, though it is difficult to think of such a condition.

Level culture should mean not only a level surface exposure when the work is completed but it should also be made to mean the cutting or stirring of a slice or layer of the surface to practically the same depth at all points. This is usually best accomplished by using a long, flat blade which is run so as to cut an even depth and at the same time stir the soil before it falls back in position. Another means almost as effective is the use of a large number of small shovels. Even small shovels leave an uncut ridge underneath, and a slight corrugation on the surface. Large shovels are extremely harmful since they leave the surface in great ridges and portions of the uncut under-surface exposed to the air.

### **Seeding and Planting**

All seeding and planting should be done with a machine that will deposit the seed in the moist soil at an even depth and leave a loose surface over it. The depth at which the seed should be sown will vary with the size and viability of the seed quite as if sown under humid conditions, but in dry

farming the seed must be deposited not a certain depth below the surface of the soil, but a certain depth below the top of the moist soil. This is an important point. Not infrequently, deep planting will be required, but there is little danger in planting deep under dry farming conditions for the reason that the young plants readily push to the surface through the loose dry surface mulch. Should the seed be deposited in the dry surface mulch it will lie there until a shower comes or until the moisture from below is brought up to it by rolling or other similar treatment.

### **Fall Seeding of Cereals**

Plowing is a rather slow operation, much slower than discing, and therefore, as soon as the crop is removed from the field (the removal of the crop should be expedited as much as possible) double disc the land by lapping one-half. By discing an excellent mulch is formed upon the surface, thus preventing the loss of large quantities of moisture during the time required to complete the plowing of the land and any rain that may fall sinks quickly into the soil. Furthermore, discing puts the soil in very much better condition for plowing for the reason that the soil will come up in very much better condition after being disced. The plowing should be of such a depth as seems consistent with the character of the soil. (See plowing). It may be found advisable to subsoil.

Seed with a hoe drill rather deeply, say, one inch in moist soil which may make three or four inches below the surface if the dry dust mulch is included in the measurement. The hoe drill covers the seed with a loose layer of soil which prevents the drying out of that portion of the soil surrounding the kernels. Should it happen that the surface soil in which the seed must be sown is too dry for the proper germination of the seed, if it is too late to wait for a shower, there are two methods of procedure that may prove successful. Either sow with a press drill, which leaves the soil over the seed firmed and in turn will increase capillarity from below, pos-

sibly supplying the needed moisture to the seed; or immediately after seeding roll the field. Rolling will firm the whole surface and by diminishing the size of the capillary tubes will increase capillarity from below, thus increasing the moisture content of the soil surrounding the seed, which may be expected to cause a normal germination. In most sections the seed should be sown not later than September 15th for the reason that by so doing all of the fall rains are rendered available to the crop. As soon as the plants are up, the surface mulch should be immediately formed again by cultivation with the harrow.

Every time the surface mulch is destroyed by rain, it should be reestablished by surface culture with the harrow, or better the weeder, just as soon as it is possible to go upon the land. In the spring surface cultivation should follow each rain or as often as the surface becomes compacted by the settling of the soil particles together, at least until the crop begins to stool or tiller.

Under very trying conditions intertillage has been practiced with cereal crops. It is doubtful if such a system would prove practicable, although a test of its feasibility on a small scale would be commendable. When the crop is six or eight inches high it shades the surface of the soil so effectually that thereafter the surface loss by evaporation is minimized.

In a dry climate harvesting should begin when the crop is rather green so as to avoid loss by the shattering of over ripe grain.

### **Spring Seeding of Cereals**

Spring seeding requires the same careful preparation of the field the previous season as fall seeding. The treatment of the soil should be identical with that described under fall seeding with the possible exception that the soil should be cultivated as assiduously when there is no crop as when there is a crop growing upon it. No weeds should be allowed to grow as they pump water out of the soil, and therefore, rob

the coming crop of a portion of its moisture. However, if cultivation is sufficiently frequent and thorough to keep up a perfect dust mulch there will likely be very little trouble from weeds.

In the spring cultivate with the weeder as early as possible. A little later when the soil has dried out somewhat give it a deeper surface cultivation either with the acme harrow or the disc. Sow as early as the conditions are favorable. Seed with the hoe drill as in the fall. Cultivate frequently with the weeder in order to maintain a loose mulch and continue the cultivation at least until the grain stools.

#### **Fall vs. Spring Seeding of Cereals**

The time of seeding will depend much upon the time of the rainy season and the distribution of the snow or rainfall. Whether to seed in the fall or spring must be determined after a study of the local conditions. Under a condition where the principal rainfall occurs in mid-summer it may not be practicable to seed in the fall. If there is not sufficient moisture at all times between the time of seeding and the rainy season, to carry the crop properly, spring seeding must be substituted. It may even be necessary to seed rather late in the spring on occasion when the early spring is unusually dry. But wherever there is sufficient moisture to properly carry the crop along or under a condition where a large portion of the total precipitation occurs in the fall, winter and early spring, fall seeding is always preferable. Seeding, of course, must always be done at a time when the crop will make the best use of the available soil moisture.

Fall seeding assists materially in the retention of the soil in place about the plant roots because there is a considerable growth above ground before the usual windy season sets in. Herein lies one of the great values of fall seeding.

#### **Amount of Seed to Sow**

The quantity of seed that should be sown per acre diminishes with the decrease in the amount of soil moisture available to the crop. If, for example, five pecks or 75 pounds of

wheat is required for seeding in the humid sections, from one and one-half to three pecks or from 20 to 45 pounds, varying with the precipitation, etc., would be sufficient in the semi-arid belt. The wide difference in the amount of seed required in the humid and the dry farming sections is explainable in the fact that it requires approximately a given quantity of water to produce a bushel of grain. Therefore, if twice as many seed are sown as there is sufficient moisture available in the soil to bring to maturity, all of the seed will grow until one-half or two-thirds mature and there it will stop, for all of the moisture is exhausted. If only one-half the seed had been sown we may assume that up to the same date only one-half of the total soil moisture would be consumed, thus leaving the other half with which the crop could come to maturity. If somewhat too small an amount of seed is sown stooling will be more vigorous and the root development correspondingly more expansive; so that within certain limits the crop will adjust itself to the moisture conditions.

Should a field of grain start off well after seeding, grow luxuriantly for some weeks and then wither and die, do not be too hasty in placing the difficulty. There may be a single or a combination of reasons. A sufficient storage reservoir may not have been formed; the moisture stored may not have been properly conserved before seeding; the after cultivation may have been carelessly done or neglected altogether; or possibly far too much seed may have been sown for the quantity of moisture available. If any one or all of the other conditions should exist, the importance of the last factor would be increased.

### Yields

It is absurd to believe larger yields can be secured under dry farming conditions than in the rain belt or irrigated sections, unless there be other conditions which bear upon the results other than the amount of water. It requires very nearly the same quantity of water to produce a given product in the different sections, but the difference seems to be in favor of the humid sections. To be just in our consid-

eration of the matter, it must be added that there are certain superior conditions in the semi-arid belt which tend to offset this difference,—cheaper land, easier cultivation, etc. But after all is said pro and con it must be admitted that dry farming crops are as a rule smaller, and often much smaller, than those grown in the humid belt or under irrigation.

It is far from the writer's intention to discourage the practice of dry farming. In fact the purpose of this publication is to assist and encourage dry farming. Let the yields be smaller. Remember that these crops are grown upon exceptionally cheap lands and in sections where large holdings are not only tolerated but must necessarily be encouraged. Profits, in the end, must be figured upon the investment plus the cost of the working force whether it is man, beast, or machinery, and no such yields are necessary upon \$10.00 and \$20.00 land as upon \$50.00 and \$100.00 land in order to realize a fair profit. A yield of 15 bushels per acre is much better on \$20.00 land than 30 bushels on \$50.00 or \$100.00 land. Furthermore, the conditions are most favorable for extensive operations, whereby the profits may be increased in proportion to the area and investment.

#### **Caring for the Crops**

After the expense of growing a crop is borne, care and judgment should be exercised in harvesting and storing. If crops are to be used for hay, cutting should be done when the seed is in the early dough stage. If the area is large and the force small then cutting must begin somewhat earlier in order to care for all the crop before it has ripened its seed sufficiently to shatter badly. The curing for hay should be in as thick layers as practicable under the climatic conditions, so that there will be as little exposure to the air as possible, and of course the operation of gathering and stacking when cured should be as rapid as possible.

If the forage is to be fed to stock on the farm, storage barns and sheds will quickly pay for themselves. Crops that are to be harvested for their seeds should be cut somewhat before

they are dead ripe. If left until fully ripe before harvesting is begun much of the crop may become too ripe before it is completed, resulting in a great loss of grain by shattering when it is being hauled. This is particularly true in dry farming districts for the reason that the atmosphere is usually rather dry, and therefore it quickly removes the moisture from the crop when nearly ripe. It is important to provide graneries for the storage of grain. Provision should not only be made in this way against the damage that may occur from the weather, but also for protection against insects and vermin.

### **Disposal of the Crops**

The method of disposal of crops under dry farming will, like those grown in humid regions, depend upon the conditions, such as nearness to market, the character of the available markets, the climatic conditions relative to stock raising etc. Near large cities or towns the products of the farm may find ready sale in bulk at good prices or portions of the crops may be used in the production of dairy and poultry products. Far out from ready markets where the haul will be great the farmer must resort to other methods of disposal of the crops not used directly or indirectly in the family food supply.

Usually stock feeding will be found the simplest and probably the most profitable method. Sheep and hogs may safely be placed at the head of the list for feeding purposes under present market conditions, although the fattening of the different classes of cattle and the feeding and fitting of range grown horses for market and sale, may reasonably be expected to share in the disposal of farm products. To sum up the whole question, wherever markets are near and ample the products may be marketed in bulk as grown, but wherever the haul to market is long there must necessarily be made a search for methods of concentrating the farm products into secondary products which, because of their reduced bulk and increased value, may be hauled to market



cheaply or like fat stock or fitted horses, can be made to carry their own weight to market with little loss or expense.

### Implements

There are a number of farm implements which are essential to success in dry farming. The success of dry farm operations may often hinge upon the employment of the right kind of farm machinery. Every farmer who expects to be successful should use the following machinery or others that will prove equally effective: Stirring plow, subsoil plow, sub-surface packer, roller, hoe drill or seeder, disc, surface cultivator, acme harrow, toothed harrow, weeder, harvester, and thresher. All of this machinery should be of large draft requiring in most cases from four to eight horses, so that a very wide strip may be treated every time the field is crossed. One man, or often one boy can handle six or eight horses as well as two and thus greatly cheapen the cost of each operation. Every machine should be so equipped that the driver can ride at all times, if he so chooses, and the seat should be so located that he will feel the least inconvenience from the effects of the dust or rough ground. Of course a traction engine may be employed in the place of horses or mules if conditions are favorable. Engines are extremely effective since time is saved and large amounts of work can be performed when the soil is in the best condition.

Not infrequently new settlers in dry farming sections will feel unable to purchase the complete outfit of machinery required. However, no excuse is sufficient for doing without implements that can possibly add to the efficiency of the work, cheapen the cost of production, or render the operations more speedy. If the money cannot be borrowed or if it seems undesirable to go in debt for so much machinery, let a half-dozen or more farmers unite, form a cooperative association, and together purchase the needed outfit. Rules providing for the alternate use and for the repair of the different machines may readily be formulated. Every farmer will need certain implements. Those can be purchased in grea-

ter numbers. Of certain implements, a single machine may often serve for a number of farmers.

### **Experiments**

Every farmer should do some experimental work. The manufacturer is continually experimenting in order to discover new and better methods. The farmer should also investigate so as to keep abreast of the demands of the times. His experiments should be on a small scale so that, should the results prove disastrous the financial loss would be small. All large problems involving much time or large expense should be turned over to the Agricultural Experiment Station, but there are many smaller problems that require study in each locality. Great care should be taken to undertake the solution of only one thing at a time making all other conditions as nearly identical as possible. Thus erroneous conclusions may be avoided. Whenever in doubt as to the interpretation of the results, correspond with the Territorial Experiment Station authorities. They will be glad to render assistance.

### **Important Things to Do**

1. Give attention to detail.
2. Double disc by lapping one-half as soon as the crop is removed.
3. Plow deep, from 8 to 12 or more inches before the rainy season sets in.
4. Form a level, fine surface after plowing before leaving the field each half day.
5. Renew the surface mulch as soon after every shower as the soil is dry enough to work without puddling.
6. Cultivate at intervals of from two to four weeks whether it does or does not rain.
7. If the ground was plowed in the fall, cultivate with a light harrow as early in the spring as possible, following this by a deeper cultivation when the soil has dried out somewhat more deeply.
8. Sow or plant rather deeply with a machine that will

deposit the seed at an even depth in the moist soil beneath the surface dust mulch leaving a loose surface above.

9. After seeding cultivate at frequent intervals, and as soon after each rainfall as possible, suiting the cultivation in frequency, depth and continuance to the crop and the conditions prevailing.

10. Begin harvesting rather early and remove the crop from the field promptly.

11. Use machinery of large capacity.

12. Read and study books, bulletins, magazines and periodicals dealing with dry farming and with agriculture in general.

#### **Dont's**

1. Don't neglect details.

2. Don't expect heavy crops, but make up for the yields by cultivating extensive areas with machinery of large capacity.

3. Don't expect every year to be a banner year; bad seasons will come.

4. Don't expect to succeed without deep plowing.

5. Don't expect to succeed without frequent cultivation.

6. Don't sow or plant thickly.

7. Don't be too quick to lay the blame upon the soil, or the weather, it may be your fault.

#### **Some Results Obtained in the Las Vegas District**

Dry Farming has been practice in the vicinity of Las Vegas by a few farmers for several years and by several farmers for a few years. The conditions seem to be favorable for dry farming operations over a wide area in this district as the following pages will indicate:

The information given below regarding the actual methods followed in growing the various crops reported was secured direct from a few farmers (there were a number of others) by submitting to each the following list of questions:

I. Character of soil and subsoil.

II. Plowing

1. Date
2. Method
3. Depth
4. Machinery used
5. Moisture Condition
- III. Cultivation between Plowing and Seeding
  6. Dates
  7. Method
  8. Depth of each
  9. Machinery used
  10. Conditions of soil
- IV. Preparation of Seed Bed
  11. Date
  12. Method
  13. Depth of each operation
  14. Machinery used
  15. Soil condition
- V. Seeding or planting
  16. Date
  17. Method
  18. Depth
  19. Quantity of seed per acre
  20. Machinery used
  21. Condition of soil
- VI. Cultivation
  22. Dates
  23. Method
  24. Depth of each
  25. Machinery used
  26. Condition of soil
- VII. Harvesting
  27. Date
  28. Method
  29. Machinery used
- VIII. Threshing
  30. Date
  31. Method

- 32. Machinery used
- 33. Yield,—grain, straw (stover), pasture
- 34. Quality
- 35. Value

IX. Remarks

Each crop has been treated separately and in every instance, the name and address of the grower, accompanies his answers. Anyone is at liberty to seek corroboration of the statements by direct correspondence.

Mr. T. T. Turner, Las Vegas, N. M.

*Farm located three miles north of Las Vegas.*

Oats

The soil upon which I grew my oats crop is adobe to the depth of about six feet with a mixture of sand and gravel lying immediately below this which goes to make up the sub-soil.

My land was plowed between March 1st and 15th, using a sulky plow drawn by three horses which cut 12 inches wide and ran from 7 to 9 inches deep. At the time of plowing the soil was in good condition and since I was desirous of conserving all possible moisture I had it disced and then smoothed with a drag which consisted of four pieces of timber 8x8 inches by 8 feet long, chained together.

During the time between plowing and seeding I practiced no interculture and cannot therefore answer your question concerning this step in dry farming.

My crop of oats were seeded with a hoe drill to a depth of about 2½ to 3 inches with the rows 7 inches apart. Each day's seeding was run over by the float described above, either on the day of seeding or the next. The moisture was about 1 inch below the surface of the ground.

The cultivation given to the oats was simple but I endeavored at all times to conserve the moisture in the soil. The operations consisted in going over the entire field twice with a weeder, the first, just as the oats were coming up, and

the second, when they were 4 or 5 inches high. I noticed that the moisture was about two inches below the surface at the time of the first cultivation; that the ground was becoming dry at the time of the last; and that the weeder made the surface soil fine or, in other words, made an excellent earth mulch.

The oats were mowed for hay with a mowing machine on August 10th,—when the straw was just commencing to ripen and the seed was in the dough stage. It was stacked like hay as soon as it was in proper condition.

The yield for this crop can be safely estimated at  $3\frac{1}{2}$  tons per acre. No pasture was obtained. I value the hay at \$10.00 per ton in the stack on farm.

My experience in growing oats has led me to advise and to practice cultivating the crop with the weeder after each rain until the crop is fully 6 inches high. On my soil a light shower causes the ground to crack badly and it must be cultivated. During my eight years practice with dry farming I have never cultivated more than 3 or 4 inches deep.

### Sorghum

The sorghum ground was somewhat higher and of a lighter consistency than the field upon which the oats were grown.

Between April 15th and June 1st sod ground which had never been cultivated before was plowed to a depth of about 4 inches with a sulky plow. Plowing was done only when the soil was in good moisture condition. If the ground appeared too dry the plowing was discontinued until a shower came. The plow was followed each day by a disc which in turn was followed by a toothed harrow.

One-half of the sorghum was planted on May 25th and the other half on June 15th with a hoe drill. The seed was not well covered on account of the undecayed sod. In order to cover the seed fully, the field was disced once, followed by the float. In the case of the first planting the ground was quite dry and there was only about one-half of a stand, but with the second planting the amount of moisture was suffi-

cient for germination and a good stand was obtained. Sowed about 45 pounds of seed to the acre on the first half and about 75 pounds on the second half.

The first seeding was given no culture whatever, the second was cultivated with a weeder,—going over a portion of the field once and the remainder twice. The weeder was used the first time when the crop was just coming up and the second time when it was two or three inches high. The weeder penetrated the soil to a depth of from one to one and one-half inches. The moisture content was ample.

The sorghum was mowed between September 16th and October 1st. The crop was allowed to lie on the ground about one week before raking and shocking. It remained in the shock about three weeks when, although it was still green, it was stacked like hay.

The yields can be safely estimated at 4 tons per acre for the first planting and at  $1\frac{1}{2}$  for the last. I did not dispose of the crop but consider it worth \$10.00 per ton for stock feed upon the farm.

There was quite a difference between the first and second planting and I could plainly see that the last was too thick. The plants crowded each other so much that the crop could not grow tall.

Although this is the first year I have tried dry farming, I believe it can be made a great success.

Mr. Isidoro V. Gallegos, Isidor, N. M.

*Farm located 55 miles southeast of Las Vegas on the extreme eastern side of the Las Vegas mesa.*

During the past season I had good success with sorghum, melons and squash and will give you data on these three crops, considering sorghum first.

### **Sorghum**

A good dark loam prevails on my farm with a subsoil of clay below.

Between May 25th and 30th I plowed the ground embraced

in the sorghum field with an 8-inch walking, stirring plow, turning the ground to a depth of about 6 inches. The soil was in excellent condition. Instead of harrowing or smoothing the surface I allowed it to remain rough just as it had been left by the plow. No further attention was given the land until the time of planting.

On June 4th I planted the sorghum by plowing a second time to a depth of 5 or 6 inches and dropping the seed in hills  $3\frac{1}{2}$  to 4 feet apart in every fourth furrow which left the rows from  $3\frac{1}{2}$  to 4 feet apart. At the time of seeding the soil was moist and in excellent condition.

No cultivation whatever was given to the crop.

The crop was mowed between October 4th and 15th, then shocked and later stacked the same as alfalfa.

The area embraced in field was 2 acres which yielded approximately 12 tons or 6 tons per acre. The sorghum grew about eight feet high, and presented an excellent showing for dry farming. In quality it would be classed good, and would have sold for \$4.00 per ton on the farm.

The crop received no water whatever except rain and no water flowed on to the field from higher ground. I think sorghum is a good crop for dry farming.

### **Melons and Squash**

Let us now proceed to the consideration of the water melons, musk melons and squash which I harvested from a field adjacent to the sorghum field. The soil is the same as that in the sorghum field.

The ground was plowed and otherwise treated in the same manner as the sorghum field except that the plowing was done June 4th and 5th.

The water-melons, musk-melons and squash were planted on June 5th in hills 6 feet each way, ten to twelve seeds in the hill. About 50 percent germinated. The seed were covered 3 inches deep with an ordinary garden hoe. The soil was in good condition at the time of planting.

There was one acre of water-melons and one-half acre each



of musk-melons and squash. Although the crops were very good many loads being hauled from the field, I cannot give exact yields. Some of the individual weights recorded were: One squash, 70 pounds; one water-melon, 35 pounds; and another 42 pounds. In quality these crops would have been hard to surpass. On account of the method of harvesting I am unable to tell you the amount of money realized from my crops.

No water reached the land except rain water.

I am of the opinion that these crops could be grown almost every year since the rainfall was more scanty than usual this season. Even the grass on the ranges was poorer than common.

Dr. M. M. Milligan, Las Vegas, N. M.

*Farm located two miles east of Las Vegas on the mesa.*

### Corn

A heavy loam from 2 to 12 feet deep underlaid by a shale constitutes the soil and subsoil respectively on my farm.

The ground was plowed about 4 inches deep between April 28th and May 1st. The ground was soft and mellow, and in excellent condition.

The seeding was done between April 28th and May 1st and consisted of dropping the corn in the furrows when plowing.

The crop was given two cultivations,—one on June 10th and the other about August 1st. Used a 1-horse 6-shovel plow (Planet Jr.) running to a depth of about 3 inches for the first operation and a 1-horse 10-inch stirring plow running to a depth of 4 inches for the second. Plenty of moisture was in the ground at the time of each cultivation.

The corn was cut close to ground between October 10th and 12th with an ordinary corn knife while it was still green.

After cutting, it was hauled on a sled and placed in long shocks 20 feet in diameter. It cured without decaying. I feed to stock from the large shocks. The yield I would estimate at 4 tons of dry fodder per acre, worth \$5.00 per ton in the shock.

I planted two kinds of corn, one Mexican June and the other a Kansas yellow corn. Including this year I have grown three crops of corn without a failure. From my experience of three years I believe that if the proper method of plowing and culture are practiced one can grow corn almost every year. I believe the following crops can be grown: White Navy beans, barley, rye, field peas, and fruit trees. I have Siberian crab, peach and cherry trees planted and they are growing in fine shape this year. I have given them no other cultivation than that received by the crop planted between the rows.

Mr. J. Thornhill, Las Vegas, N. M.

*Farm located three and one-half miles north of Las Vegas.*

#### Oats

The soil upon which my oat crop was grown consists of a sandy loam from 1 to 3 feet deep underlaid with a subsoil of joint clay which has a tendency to form a hard pan.

I plowed one-half of my field during November and December, 1905, and the remaining half during February this year. The ground was stirred to a depth of from 6 to 8 inches with a 12-inch plow drawn by three horses. The plow was arranged with a wheel attachment on the front and since the soil was even the depth varied little. The soil was in good condition for plowing. Always disced one day what I plowed the previous day in order to form an earth mulch and check evaporation.

I paid close attention to conserving the moisture between plowing and seeding. Between April 15th and 25th, the field was disced twice, once each way, to a depth of 6 inches using an 18-inch disc drawn by three horses. Following immediately behind the disc came a toothed harrow running about 3 inches deep and drawn by two horses. These operations left the ground in fine condition.

The seed was sown 3 or 4 inches deep with the hoe drill between April 15th and 25th. The drill rows were 8 inches apart.

Sowed 90 pounds of seed per acre. Followed the seeder

immediately with the harrow, having the bars down so that it had the effect of a smoother. No cultivation was given the crop after planting.

The harvesting was begun on August 25th. Used a McCormick self-binder drawn by three horses. Shocked immediately and stacked from September 16th to 20th.

The yield was  $71\frac{1}{2}$  bushels per acre of 32 pounds to the bushel. The straw was of good quality and the grain was medium to good. The grain is worth  $1\frac{1}{2}$  cents per pound now, but it will be worth 2 cents after January 1st, 1907.

I used no irrigation water. I have grown oats during the years 1900, 1902, 1903 and 1904 and corn in 1901 and 1905. Out of the five years three good crops were secured and about two-thirds of a crop the other two years. In 1906 the yield of oats was  $72\frac{1}{2}$  bushels per acre on nine acres. From my experience, if the ground is properly prepared and properly planted, good crops can always be secured and especially is this true if the ground is plowed in the fall. I find it best to disc and harrow the ground after plowing so as to conserve moisture. The variety sown was White Russian and the seed was obtained from a local farmer.

### Wheat

The ground upon which my wheat crop was grown consisted of a rather shallow, rocky, sandy loam about 2 feet deep, below which there was a shale. The land was plowed in the early days of March. Five acres of the field had never been broken up before. Used a 12-inch stirring plow which run from 6 to 8 inches deep.

Sowed the wheat broadcast on February 25th, and covered with a toothed harrow which run about 3 inches deep. The ground was in good condition. Sowed 100 pounds of seed per acre. No cultivation was given after planting. Used a McCormick self-binder. Harvested the crop on August 24th and shocked immediately. Stacked on September 5th.

The threshing was done in the same manner and at the same time as was the oats. Received a yield of 10 bushels of

grain per acre and about one-half ton of straw. The quality of the grain was fair to good. Received  $1\frac{1}{2}$  cents per pound for the grain and \$8.00 per ton for the straw.

The seed for this wheat was purchased from the mill for chicken feed and was sown by mistake by my two boys. I do not consider this method a good one for wheat seeding and will never use it again.

I grew two acres of wheat in 1900 which yielded an average of 25 bushels per acre. I have had no other experience with wheat, but believe it can be grown without irrigation if properly planted and the ground is properly prepared. I am of the opinion that oats pay better than wheat ordinarily and that one should secure seed from reliable sources and sow with hoe drill, smoothing after seeding.

### Corn

The character of the soil and the time and method of plowing the corn ground was identical with that of the oat field. The planting was done at the time of plowing, between May 1st and 15th. Plowed with an 8-inch stirring plow which run about 4 inches deep. The corn was dropped in every third furrow, from three to four grains to the hill, thus bringing the hills about 3 feet apart each way. The soil was in good condition at the time of planting and the seed germinated well. Immediately after planting the field was gone over with a harrow laid flat. Hoed once in the row just as soon as I could see the crop above the ground and followed this immediately with a 1-horse Planet Jr. A second cultivation was given in about three weeks. The ground was in good condition each time it was cultivated.

The crop was cut and shocked on September 25th, twelve hills square. Husked the corn between October 17th and 26th.

I estimate the yield of grain at about 50 bushels. Shelled corn on the city market is worth  $1\frac{1}{2}$  cents per pound. Ear corn would probably bring 75 cents per bushel of 70 pounds. The variety grown was White Australian.

I have grown corn for the last seven years regularly. Of these years, two gave excellent crops, four about two-thirds

of a crop, and one, 1904, about one-half of a crop. I believe that one can grow from fair to good crops of corn every year if the proper cultivation is given and if the ground is plowed in the fall. This year I grew  $1\frac{1}{2}$  acres of field corn and  $\frac{1}{4}$  acre of pop corn.

### Alfalfa

I seeded about nine acres to alfalfa in 1900 and used irrigation for the first year but none thereafter. I received two cuts in 1901, three cuts in 1903, three cuts in 1904, two cuts in 1905 and three cuts in 1906. I believe that it will be rather hard to get a good stand of alfalfa unless seeding is done during a very favorable season. If a stand is once obtained the yield will vary from  $1\frac{1}{2}$  tons per acre during poor season to 3 tons during good ones. I would class alfalfa among the crops that can be grown by dry farming and believe that there is more money in this crop than in any other because when once started but little labor is required thereafter.

Mr. S. F. Hemler, Las Vegas, N. M.

*Farm located two and one-half miles north of Las Vegas.*

### Oats

From 6 to 8 feet of clay loam goes to form the soil on my farm with a subsoil of shale. The land upon which my crop of oats grew was plowed between March 15th and April 15th, to a depth of from 6 to 7 inches with a 2-disc gang plow which cut 24 inches and required four horses to draw it. The soil was in excellent condition.

Further preparation of the seed bed consisted in smoothing the ground between April 15th and 25th with a float constructed of three 2 by 12-inch pieces lapped three inches and bolted together. The ground had become too dry during the last two or three days.

Sowed with a hoe drill between April 12th and 15th, the drill running about 3 inches deep with the rows 6 inches apart. When seeding the ground was in good condition with

the exception of that portion which was plowed during the last two or three days.

The oats were mowed between August 1st and 10th, when the grain was in the dough stage and the straw just commenced to ripen. The grain was shocked in the field like hay and later stacked.

I estimate the yield at from  $1\frac{1}{2}$  to 2 tons per acre, with no pasture to speak of. The crop was too ripe for more growth. The quality of the hay was good. I value it at \$8.00 per ton in stack on the farm.

I have grown crops of oats without irrigation for ten years, with only one failure, that during the season of 1904. For only two of the years have I cut as little as one-half of a crop, with a good crop for the other seven years. In 1906 I threshed 40 bushels per acre. I believe that good crops can be grown by dry farming every year if proper cultivation is given. Will plow in the fall hereafter so as to store moisture.

#### Corn

The soil, the plowing, the preparation of the seed bed and the seeding and planting were the same in the case of the corn crop as with the oats. Planted 200 pounds of seed per acre.

Harvested on August 1st, using the mowing machine. The yield was 5 tons per acre with no pasture. The quality of the feed was good and I regard it worth \$6.00 per ton for stock feed on my farm. I am of the opinion that corn is a good crop for dry farming although this is my first year's experience with corn.

Mr. Peter Roth, Las Vegas, N. M.

*Farm located six miles north of Las Vegas.*

#### Oats

A heavy black loam about 12 feet deep forms the soil upon the field, below which there is a mixture of sand and gravel.

The field was plowed on May 1st to 10th with a 12-inch walking plow drawn by two mules. The soil had sufficient moisture and was left in good condition.

The oats were sown broadcast on the surface before plowing. After plowing under the seed the field was disced twice to a depth of 6 inches. When one-half of the crop had been seeded, a shower came and the crop came up and grew nicely. The other half was planted about May 10th but the plants grew very slowly until about three inches high, at which time a shower came and the crop did well thereafter. No cultivation was given to the crop.

Cut with a self-binder,—one-half of the crop being harvested on October 3rd and the remainder on October 8th. It was shocked in the field. Commenced threshing on October 17th using a horse-power tread machine. Received a yield of 35 bushels of grain and 1 ton of straw per acre, both of which were first-class in quality. The grain is worth on the local market \$1 35 per hundred and the straw \$8.00 per ton.

I have tried to grow oats without irrigation on this same land for the past seven years. I have always treated the crops in the same way as described above, but have secured only two crops in seven.

Mr. J. A. Baca, Las Vegas, N. M.

*Farm located two miles northwest of Las Vegas.*

### Oats

The soil in the oat field is a sandy loam. The land was plowed between April 1st and 10th, with a 10-inch walking plow which run about 6 inches deep. The soil was in first-class condition.

The oats were sown broadcast between April 5th and 12th and covered by single discing to a depth of about 3 inches. The disc was followed by a smoother consisting of a timber 3 by 12 inches by 14 feet long. The smoothing left the seed bed in fine condition. No cultivation was given to the crop.

Harvested on September 12th, with a self-binder. Shocked immediately and the grain was stacked some ten days thereafter.

The threshing was done on November 14th with a Gray's horse-power tread machine. The oats yielded 68 bushels of grain and  $1\frac{1}{2}$  tons of straw per acre, and both were of good quality. The grain is worth \$1.20 per 100 pounds and the straw \$6.50 per ton. I gave no irrigation to this land whatsoever.

I have grown oats by dry farming for seven years and have received good crops every year. In previous years I cut for hay and found the returns good. Previous to this year I have always sown the seed broadcast on the surface and then plowed it in with a stirring plow about 5 inches deep. I believe this is a good method. I consider oats a successful crop for dry farming.

### Corn

Let us now proceed to my corn crop which was grown without irrigation this season.

The ground was plowed between May 1st and 10th, with a 6-inch walking, stirring plow, which ran to a depth of about 4 inches. At the time of plowing the soil was in excellent condition. The seed was dropped in every fourth furrow, in hills about three feet apart.

The cultivation consisted of one hoeing about June 29th, and one plowing on July 15th. The plow ran about 4 inches deep, which hilled up the soil around the corn. The ground was in excellent condition at time of each cultivation.

Topped the corn on September 10th and snapped off the ears on October 1st, leaving the stalks in the field.

I consider corn a safe crop for dry farming on sandy loam soil. Last year I grew two kinds of corn, Native Mexican and the common white. I find that the longer the seed has been used in the country the earlier the crop matures.

Francisco G. Gonzales, Las Vegas, N. M.

*Farm located on the mesa six miles east of Las Vegas.*

Have grown corn, oats, beans and beets for the last five years. Always grew two kinds of beets, sugar beets and



ordinary table beets. Have grown pumkins continuously for five years, but the crop each year has been a failure, except this one.

Always do my plowing in the spring and then drop beans and corn in furrow. Practice plowing in oats after they have been sown.

The following table shows the chemical analysis of three sugar beets dug by the writer of this bulletin from a field on the farm of Mr. F. G. Gonzales, on the mesa six miles east of Las Vegas :

| Substance Determined         | No. 1 | No. 2 | No. 3 |
|------------------------------|-------|-------|-------|
| Weight in ounces....         | 14.   | 18.   | 20.   |
| Purity of Juice per cent.... | 70.   | 73.5  | 69.6  |
| Sugar in Juice per cent....  | 17.5  | 18.5  | 16.5  |

Note.—Analysis made by Professor R. F. Hare, Station Chemist.

Mr. W. H. Comstock, Las Vegas, N. M.

*Farm located two miles south of Las Vegas.*

### Wheat

The land upon my farm which embraced my wheat, oats and spelt fields is a clay loam to a depth of about five feet, underlaid by a mixture of clay and gravel.

I did one-half of my plowing from October 15th to 30th, 1905, and the remaining half from April 15th to 25th, 1906. The ground was plowed to a depth of from 8 to 10 inches with a 12-inch sulky plow drawn by three horses. During the fall the soil was rather dry and turned up rather cloddy, but in the spring it was wet, although not wet enough to cause the soil to puddle. After plowing the ground was double disced, that is, by lapping half, to a depth of 3 inches with a 4 horse 20-inch disc. The soil was too wet to disc nicely, but the ground was not puddled.

The seed bed was prepared on April 28th with a spike-toothed harrow, the teeth set rather slanting. The ground was harrowed twice (one half-lap). The soil was rather wet

on the spring plowed land, but the fall plowed ground was in good condition.

The wheat was sown about 3 inches deep with a hoe drill from April 28th to May 2nd, 100 pounds of seed being used per acre. The ground was in excellent condition for seeding on both fall and spring plowed land. I usually harrowed immediately after sowing seed, but could not this year because it rained immediately after seeding.

The cultivation consisted in going over field twenty days after planting once with a Eureka Weeder, made by the Eureka Mower Company, Utica, N. Y. The weeder stirs the soil to the depth of about 1 inch. It was used to break up the crust which had formed over the surface of the ground.

Harvested the wheat on September 1st, with a self-binder. shocking immediately afterward.

Threshed the grain from field on September 15th with a 2-horse tread-power machine. It did a very poor job and left some grain in the straw. Received a yield of 40 bushels per acre on the fall plowed and 25 bushels per acre on the spring plowed field of both varieties. Had five acres of Durum (Macaroni) and three acres of Marvel wheat. The seed of the latter variety was purchased from John Salzer & Co., La Crosse, Wis. Both varieties were first-class wheat and the Durham weighing 64 pounds to the bushel and the Marvel 63 pounds. The wheat I value at  $1\frac{1}{2}$  cents per pound and the straw at \$7.00 dollars per ton delivered in Las Vegas.

This was the first year I have ever grown wheat. I have sixty acres of fall wheat sown on the high mesa east of Las Vegas. Broke up the sod from July 27th to October 5th. Plowed 6 to 7 inches deep; harrowed twice with a 4-horse harrow, and disced twice with a 4-horse disc lapping half each time. Seeded with an Imperial Drill 2 inches deep the drill being followed by the harrow, lapped half. All of the crop was up on October 16th. Also have ten acres on home farm sown October 17th.

### Oats

The character of the soil, the plowing, the after cultivation, the preparation of the seed bed, the date and method of seeding and the cultivation were the same as for the wheat.

grew two varieties of oats, the Golden Fleece and the National, the former being harvested six days before and the latter the next day after the wheat. Harvested and threshed with the same machinery and in the same way as described under wheat. The Golden Fleece yielded 30 bushels and the National 40 bushels per acre. About  $\frac{1}{4}$  ton of straw was secured per acre. I value the grain at \$1.40 per 100 pounds now and the straw is worth \$8.00 per ton delivered in Las Vegas. The National oats yielded 55 bushels per acre in 1903, 60 bushels in 1904 and 85 bushels in 1905. The Golden Fleece yielded 75 bushels per acre in 1905. I have grown oats for four consecutive years and the yields this year are lower than any previous year. The low yields this year were due to the fact that two hail storms came, one the last of June and the other the first of July, considerably damaging the crop. Hail has never injured the crops before since I have lived here. There is no question in my mind but that oats can be grown regularly by dry farming in this vicinity.

### Spelt

All of the operations were the same with the spelts as with the wheat, with the single exception that I sowed 110 pounds of seed per acre of seven acres and 75 pounds per acre on three acres.

The spelt was harvested just after the oats and just before the wheat. It yielded 30 bushels per acre on the ground seeded at the rate of 110 pounds per acre and 60 bushels on that seeded at the rate of 75 pounds per acre. I will sow 75 to 80 pounds per acre in future, for I find that spelt stools more freely than any other small grain. The yield of straw was  $1\frac{1}{4}$  tons per acre. Both grain and straw were of prime quality. I do not know the value of the grain, but consider

it better than oats for feed. The straw is worth \$8.00 per ton delivered in Las Vegas. I have grown spelt for two years, this year and last. In 1905 I had one acre and received 83 bushels of grain, actual machine weight. In figuring yields I used 60 pounds of wheat, 32 pounds of oats and 40 of spelt per bushel. I consider spelt a valuable crop for dry farming and believe that it will stand more drought than oats.

Mr. George W. Ward, Steward, New Mexico Insane Asylum,  
Las Vegas, New Mexico.

*Farm located three and one-half miles northwest of Las Vegas.*

#### **Wheat**

The soil where my crops of wheat, Mexican beans, Russian millet and barley were grown is a sandy loam to a depth of 4 feet, below which there is a shale.

The ground was plowed for wheat 8 inches deep on May 15th, using a 12-inch walking stirring plow. The soil turned up in excellent condition. No cultivation followed.

The seed bed was prepared on May 16th by harrowing the ground with a 3-section toothed harrow to a depth of about 3 inches, which left the soil in excellent condition for seeding.

The crop was sown broadcast on May 17th and covered with a toothed harrow. About 100 pounds of seed was sown per acre.

Harvested with a self-binder on September 12th. The grain was hauled in on September 25th and stored in one of the barns. It was threshed on October 15th, using a 2-horse tread-power machine. Received 21 bushels of grain per acre and 110 pounds of straw. The wheat was worth 1 cent per pound and the straw \$6.00 per ton, baled and delivered.

I have grown spring wheat for two years in succession and have received good yields each year. However, I believe that fall wheat would give better results. I regard wheat as a sure crop for dry farming in this locality.

### **Irish Potatoes**

Next I will consider my potato crop which was grown on a rocky, clay loam about 3 feet deep, with shale below.

The field was plowed on May 29th with a 10-inch walking, stirring plow to a depth of from 7 to 8 inches. The ground came up in good condition. The potatoes were planted at the time of plowing by dropping in every third furrow, 2 feet apart in the row with two or three pieces in each hill. After planting the ground was dragged twice with a smoother consisting of a timber 2 by 10 inches by 8 feet long. The weeds were pulled by hand on July 25. The ground was very weedy, but the soil was in good moisture condition.

The potatoes were dug on November 1st and the yield was at the rate of 2747 pounds or 57 bushels per acre. The quality was good and they were worth \$1.75 per hundred.

This is the first year I have grown potatoes, but I believe that they can be grown successfully every year.

### **Millet**

My crop of Russian millet was grown on the same kind of ground as was the wheat. The ground was plowed about 8 inches deep on May 30th. Sowed broadcast the same day of plowing and covered by harrowing twice, followed by the smoother heretofore described. No cultivation whatever was given to crop. The ground was rather dry in June.

Harvested the crop on October 8th, and threshed on October 20th. Yielded at the rate of 2590 pounds of grain and 1095 pounds of straw per acre. The straw was good and would bring about \$10.00 per ton in Las Vegas. The grain was worth 1 cent per pound.

The millet crop was very fine. The heads were well filled and the straw had abundance of leaves. I consider millet one of the best of dry farming crops. I will sow it next year for hay.

### **Barley**

The barley was sown in the same field with the millet, and therefore, the soil was identical with that on which the millet was sown. The barley crop was treated in every particular as was the millet. The stand was rather poor.

The yield was 12 bushels of grain and 1779 pounds of straw per acre. The grain is worth 1 cent per pound and the straw \$6.00 per ton. I consider barley, if properly handled, a success in every way.

### **Beans**

Mexican beans conclude the list of dry farming crops. The soil was exactly the same as the wheat soil.

The ground, which was new sod land, was plowed between June 15th and 24th with a 12-inch walking plow, about 6 inches deep. The soil was in good condition.

Prepared the seed bed by discing twice, once each way with a 12-inch disc drawn by three horses on June 22nd.

The beans were planted in rows 2 feet apart and the hills 15 inches apart in the row,  $2\frac{1}{2}$  to 3 inches deep, on June 24th. They were dropped in furrows made with a 1-shovel marking plow and covered with the same plow. About 100 pounds of seed were planted per acre. At this time the soil was in good condition for seeding.

Practically no cultivation was given. Harvested between October 10th and 13th by pulling by hand and stacking. Flailed the crop out on October 13th and 14th. Received 649 pounds of beans per acre. The beans were worth 4 cents per pound and the vines \$3.00 per ton. The vines make good cow feed.

This variety of beans will germinate and grow, producing a crop with less moisture than any other crop I know of. They are an excellent dry farming crop. I grew beans in 1901, 1903, 1905 and 1906 and have received excellent returns each year.

I received the following yields and prices for the various crops grown by dry farming during the years from 1901 to 1905, inclusive:

| Year | Crop          | Amount      | Price   | Total value |
|------|---------------|-------------|---------|-------------|
| 1901 | Mexican beans | 411 pounds  | \$ 0.03 | \$ 12.33    |
| "    | Turnips.....  | 3858 "      | 0.01½   | 57.87       |
| 1902 | Oat hay.....  | 7 tons      | 15.00   | 105.00      |
| 1903 | Mexican beans | 709 pounds  | 0.04    | 28.36       |
| 1905 | Alfalfa ..... | 15 tons     | 13.00   | 195.00      |
| "    | Wheat straw.. | 10 "        | 7.00    | 70.00       |
| "    | Wheat.....    | 5103 pounds | 0.01½   | 63.79       |
| "    | Mexican beans | 629 pounds  | 0.03    | 18.87       |

## Recorded of Daily Precipitation at Las Vegas, N. M.—1906

| Day of Month | Jan. | Feb. | Mch. | Apr. | May  | June | July | Aug. | Sept. | Oct. | Nov. | Dec. |
|--------------|------|------|------|------|------|------|------|------|-------|------|------|------|
| 1.....       | .04  |      | T    |      |      |      | T    |      |       | .04  |      | .97  |
| 2.....       |      |      |      |      |      | 2.03 | 1.26 | .06  | .07   |      | .04  |      |
| 3.....       |      |      |      |      |      | .15  | .18  | .29  | .32   |      |      | T    |
| 4.....       |      | T    |      | .20  |      |      | .42  | .02  | T     | .22  |      | .29  |
| 5.....       |      |      |      |      |      |      | .39  |      |       | .82  |      |      |
| 6.....       |      |      | T    | .11  | .06  |      | .25  |      |       |      |      |      |
| 7.....       |      |      |      | .47  |      |      | T    | .03  |       |      |      |      |
| 8.....       |      |      |      |      |      |      | 2.72 |      |       |      |      |      |
| 9.....       |      | T    |      |      | .67  |      | .15  |      | T     |      |      |      |
| 10.....      |      | .12  |      |      | .13  |      | .22  |      | T     |      |      |      |
| 11.....      |      | .14  |      |      |      |      | .22  |      |       |      |      |      |
| 12.....      |      | .42  | .06  | T    | T    | T    | .12  |      |       |      |      |      |
| 13.....      |      |      |      | .55  |      | .62  | .23  |      | .01   | .16  |      |      |
| 14.....      | T    | .34  | T    |      |      |      | T    | T    | .34   |      |      |      |
| 15.....      |      |      | T    |      |      |      | .31  |      |       |      |      | T    |
| 16.....      |      |      | .03  | .27  |      |      | T    | T    |       |      |      |      |
| 17.....      |      |      |      |      |      | T    | .01  |      | .01   |      | T    |      |
| 18.....      |      |      | .12  | .02  | .07  |      | .16  | .03  |       |      | .43  |      |
| 19.....      | T    |      | T    | .55  | .05  |      | T    |      |       |      | .15  |      |
| 20.....      | T    |      |      |      |      |      | .04  | T    |       | T    | .05  |      |
| 21.....      |      |      |      |      | T    |      |      | .72  |       | .14  |      |      |
| 22.....      |      | T    |      |      | T    |      | .67  | T    | T     | .29  |      |      |
| 23.....      |      |      |      |      | .10  |      |      |      |       |      |      | .02  |
| 24.....      |      |      |      |      |      |      | .01  |      | T     |      | .01  |      |
| 25.....      |      |      | .13  |      |      |      | .01  | T    | .15   |      |      |      |
| 26.....      |      |      | T    |      |      |      | .06  |      | .38   |      |      |      |
| 27.....      |      |      |      |      |      |      | .02  | .09  | .52   |      | .02  |      |
| 28.....      |      |      | .13  | T    |      |      | .06  | .15  | T     |      | .04  | T    |
| 29.....      |      |      |      | T    |      |      | .27  | .21  |       |      | .02  | .06  |
| 30.....      |      |      |      |      |      |      | .11  |      |       |      | .06  |      |
| 31.....      |      |      |      |      |      |      |      |      |       |      |      | T    |
| Total.....   | .04  | 1.02 | .47  | 2.57 | 1.06 | 2.80 | 7.82 | 1.97 | 1.86  | 1.67 | .86  | 1.32 |

NOTE—Compiled from the U. S. Weather Reports



**Photographs of Crops Grown in the Las Vegas District in 1906**

The following plates were all made from photographs of crops grown by dry farming methods, the land having received no water whatever by irrigation.

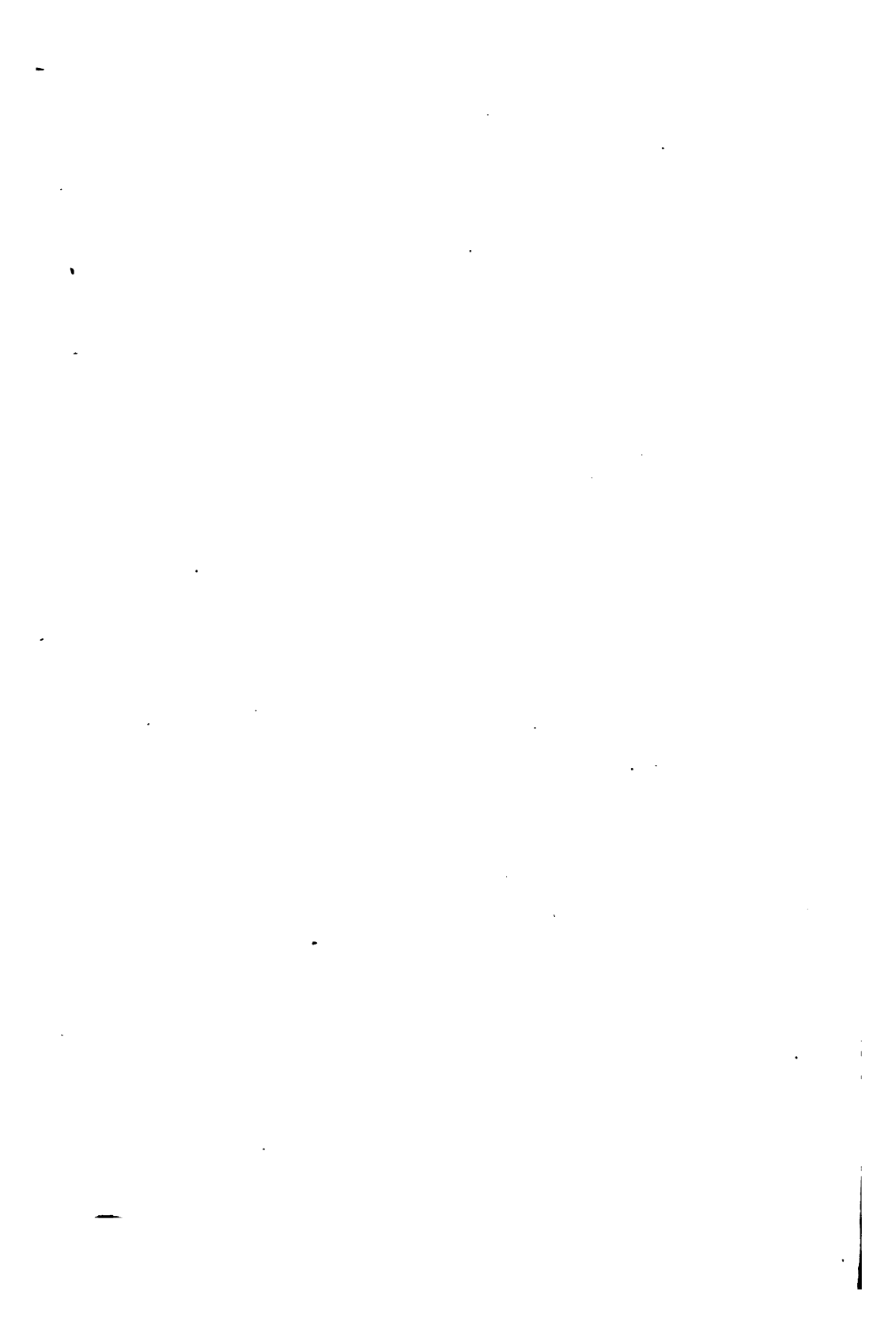
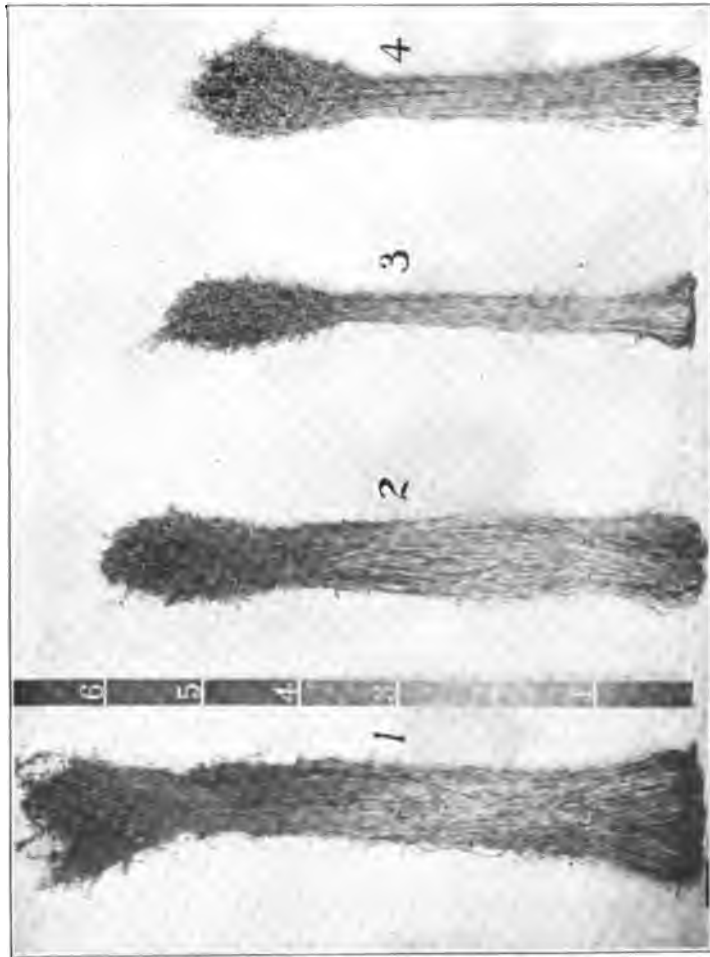
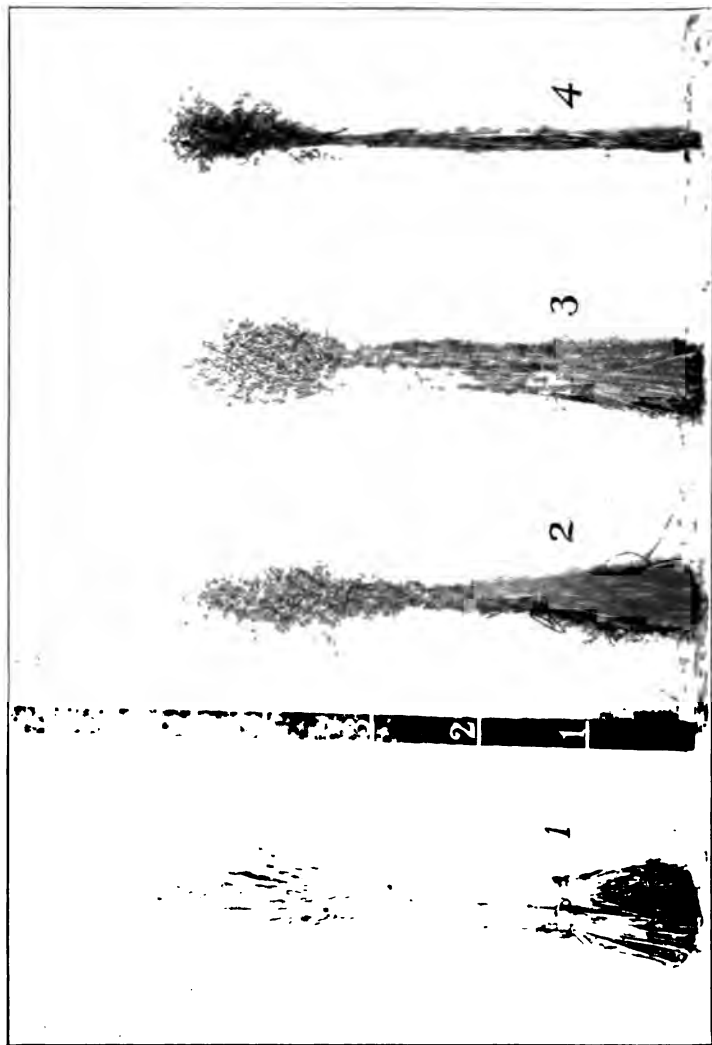


PLATE I



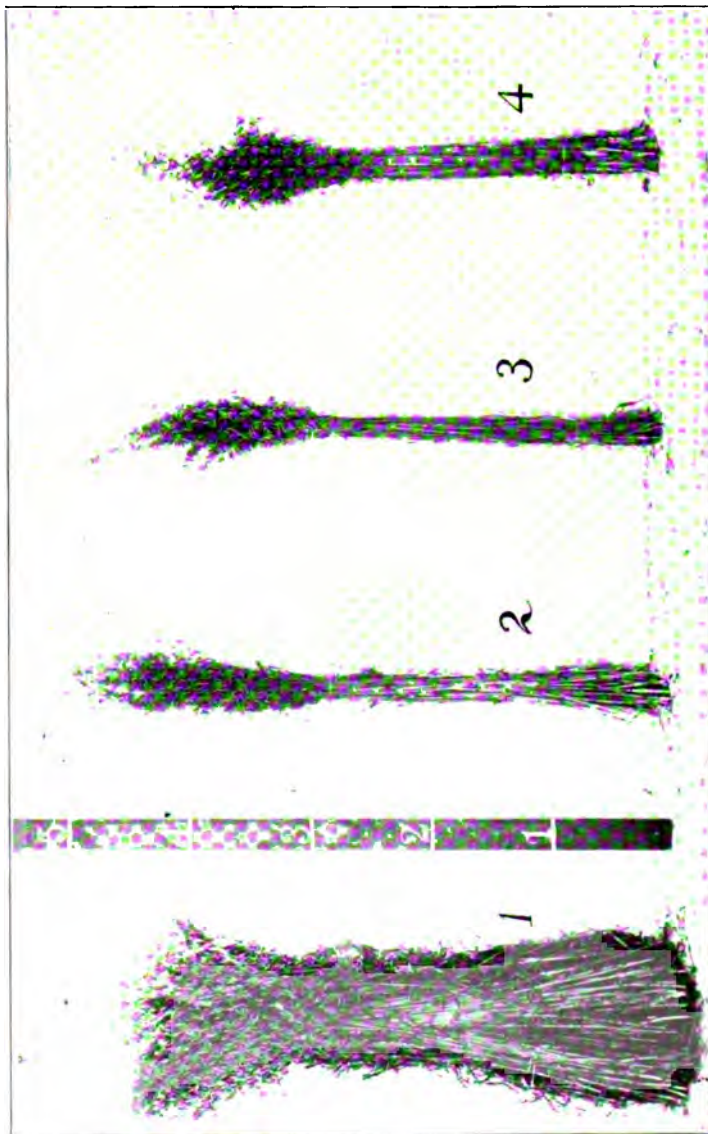
1. Oats, Charles F. Rudolph & Son, Roclacla. 2. Oats, S. L. Barker, Beulah. 3. Oats, Pedro Trujillo, Gascon. 4. Oats, Ambrocio Trujillo, Gascon.

PLATE II



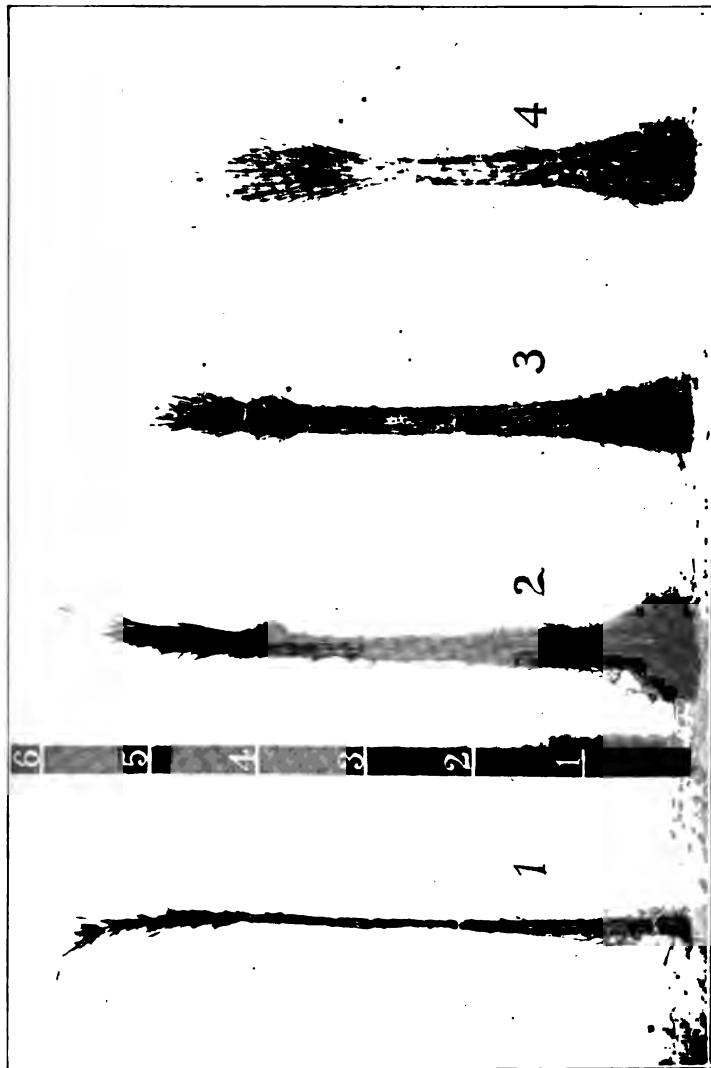
1. Timothy and Wild Grass, Ambrocio, Trujillo, Gascon. 2. Oats, Dr. M. M. Milligan, Las Vegas.  
3. Oats, J. C. & R. Maestas, Rociada. 4. Oats, J. D. Martinez, Concepcion.

PLATE III



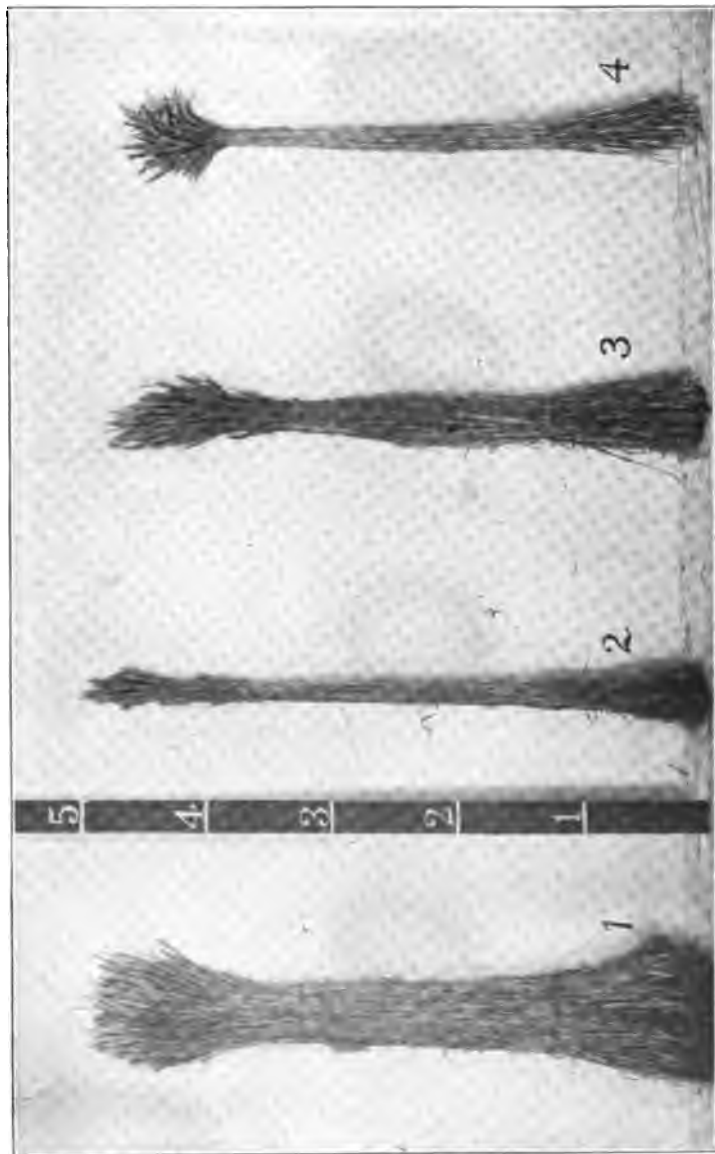
1. Oats, J. A. Baca, Las Vegas. 2. Oats, W. H. White, Las Vegas. 3. Oats, O. N. Olson, Las Vegas.  
4. Oats, Abran Suazo, Roclada.

PLATE IV



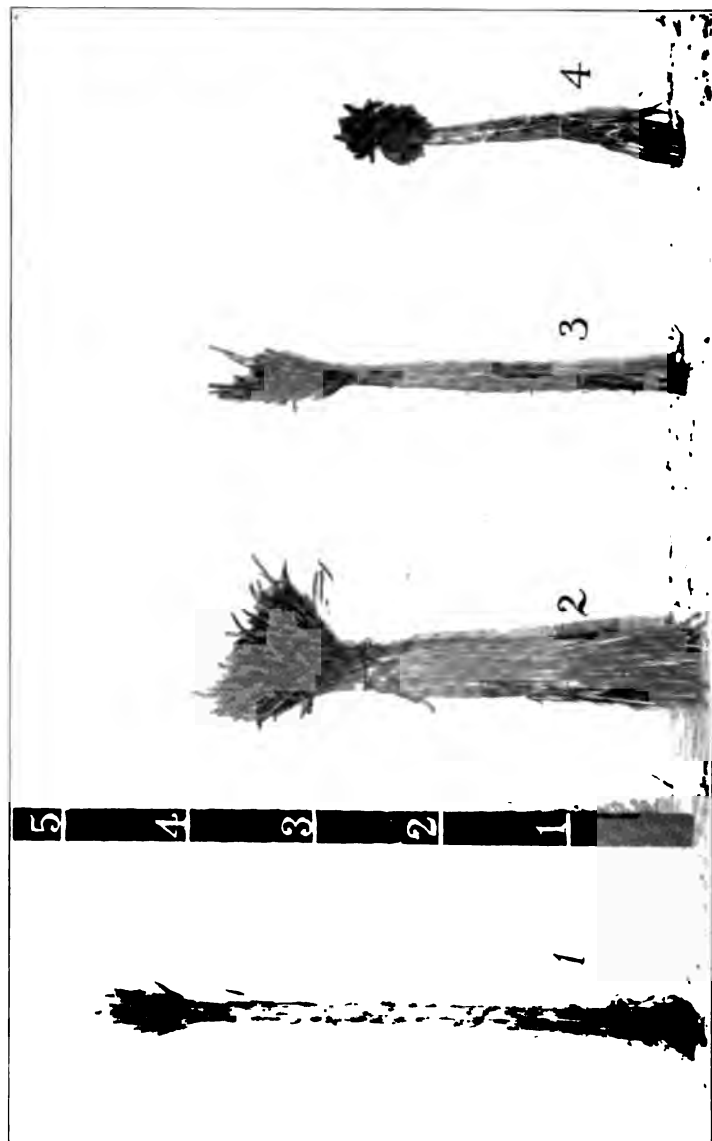
1. Crow's foot hay, Charles F. Rudolph & Son, Rociada. 2. Timothy, Charles F. Rudolph & Son, Rociada. 3. Timothy, S. R. Barker, Beulah. 4. Timothy, J. C. & R. Maestas, Rociada.

PLATE V



1 and 2. Spring wheat, Charles F. Rudolph & Son, Rociada. 3. Wheat, J. C. & R. Maestas, Rociada.  
4. Wheat Ambrocio Trujillo, Gascon

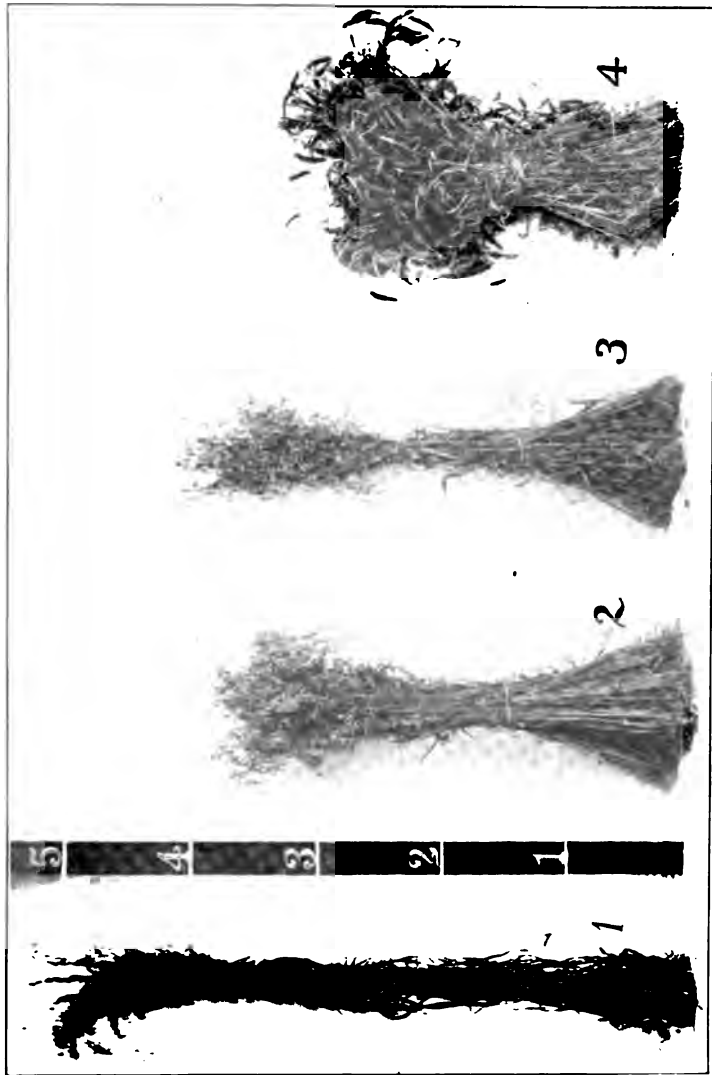
PLATE VI



1 and 3. Wheat, Abran Suazo, Rociada. 2. Wheat, Frank Cutler, Rociada.  
4. Barley, Manuel Barrego, Chacon.

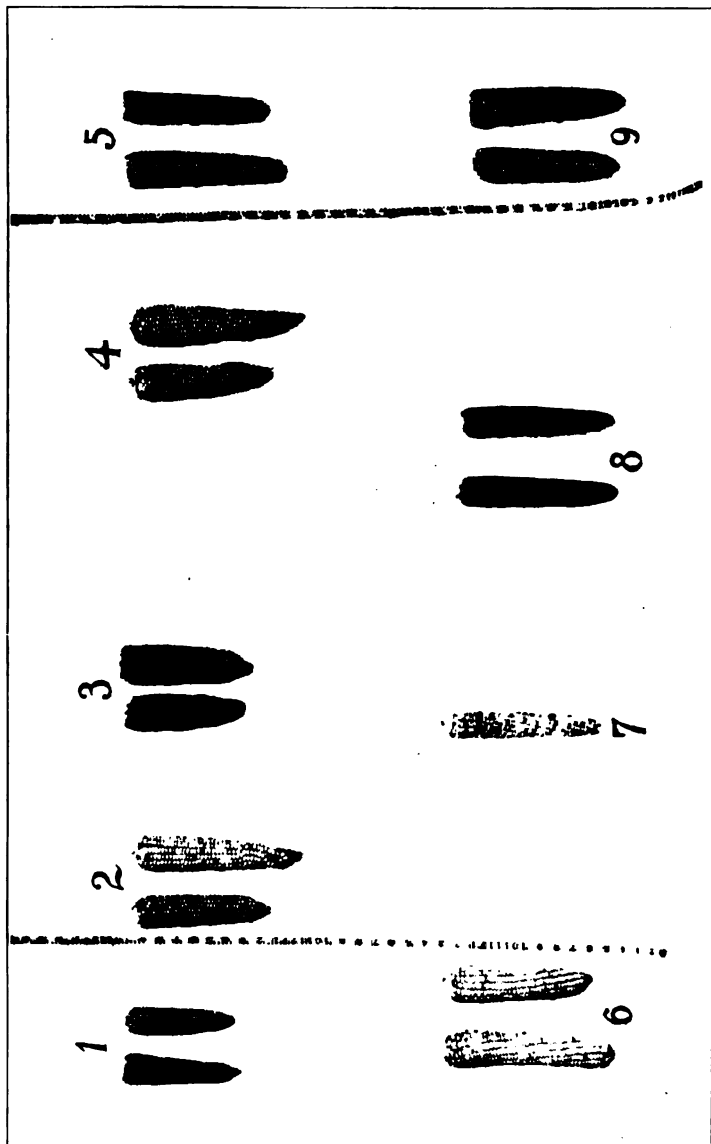


PLATE VII



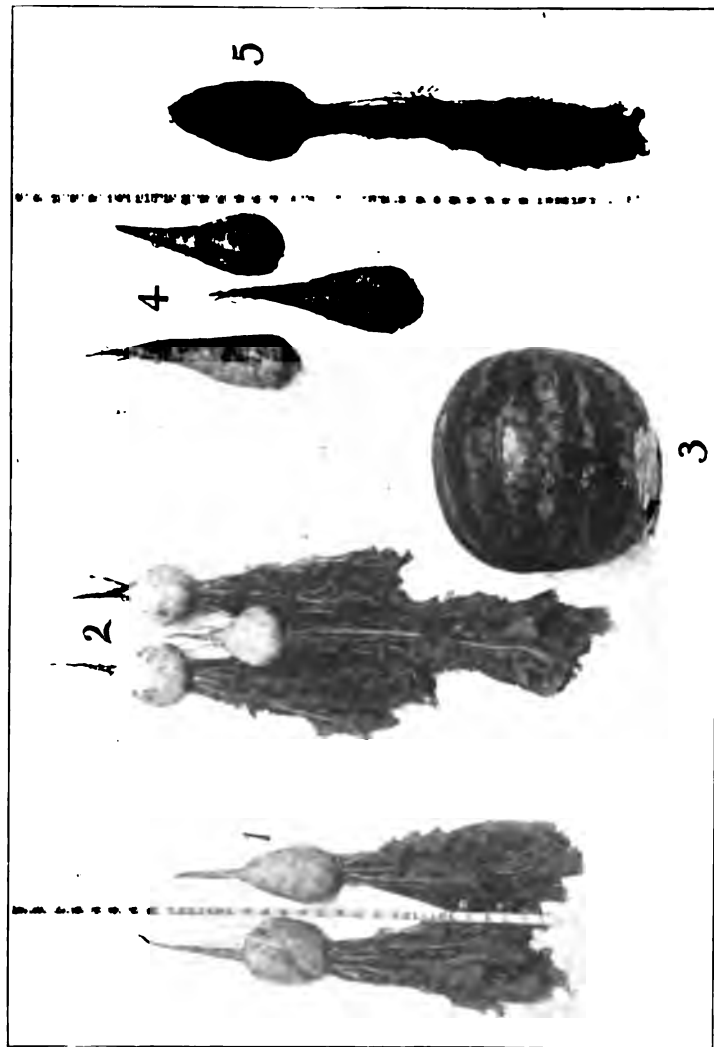
1. Oats, Peter Roth, Las Vegas. 2. Oats, Francisco Lopez, Las Vegas. 3. Oats, Campbell Dry Farm, Las Vegas. 4. Russian millet, G. W. Ward, Las Vegas.

PLATE VIII



1. Mexican Corn; 2. Mixed Mexican and Northern Dent Corn; 3. Northern Dent Corn by Dr. M. M. Milligan, Las Vegas. 4. Flint Corn, G. W. Ward, Las Vegas. 5. White Flint Corn, J. Thornhill, Las Vegas. 6. White Dent Corn, J. M. Martinez, Chaparrito. 7. Mexican Corn, Francisco Lopez, Las Vegas. 8. Yellow Dent Corn, M. Dettlerick, Las Vegas. 9. White Dent Corn, Francisco G. Gonzales, Las Vegas.

PLATE IX



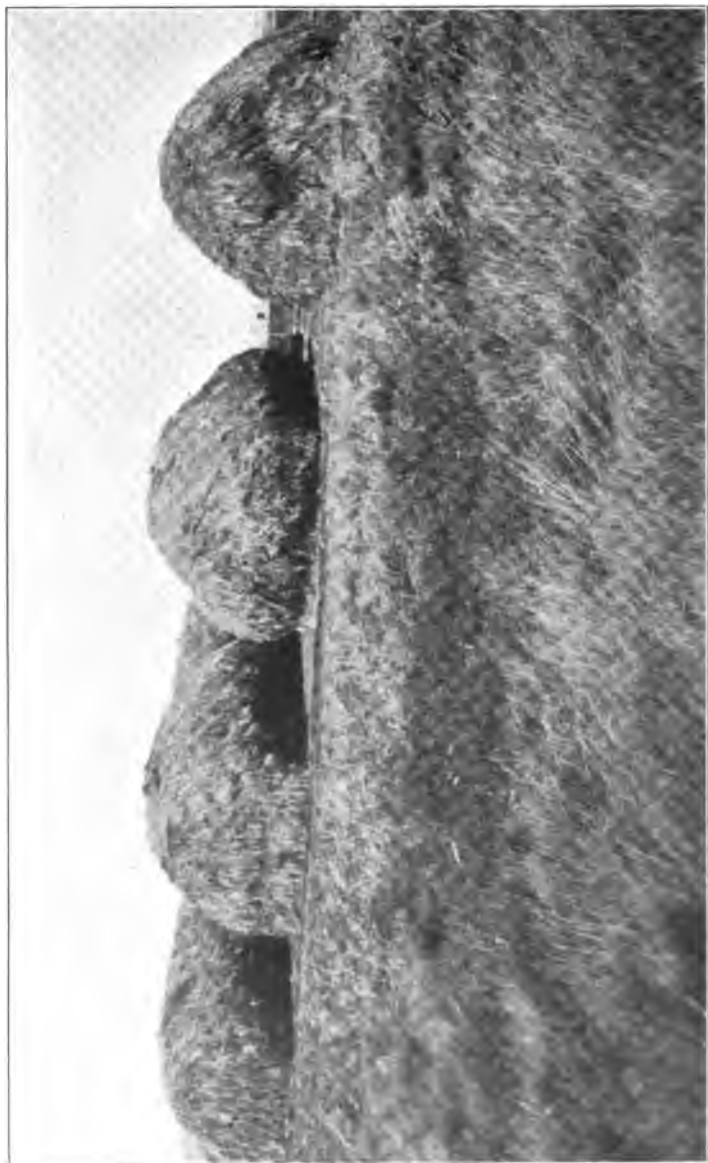
1. Turnips, J. Thornhill, Las Vegas. 2. Turnips, T. T. Turner, Las Vegas. 3. Water-melon, J. M. Martinez, Chaparito. 4. Sugarbeets, Francisco G. Gonzales, Las Vegas. 5. Carrot, Francisco G. Gonzales, Las Vegas.

PLATE X



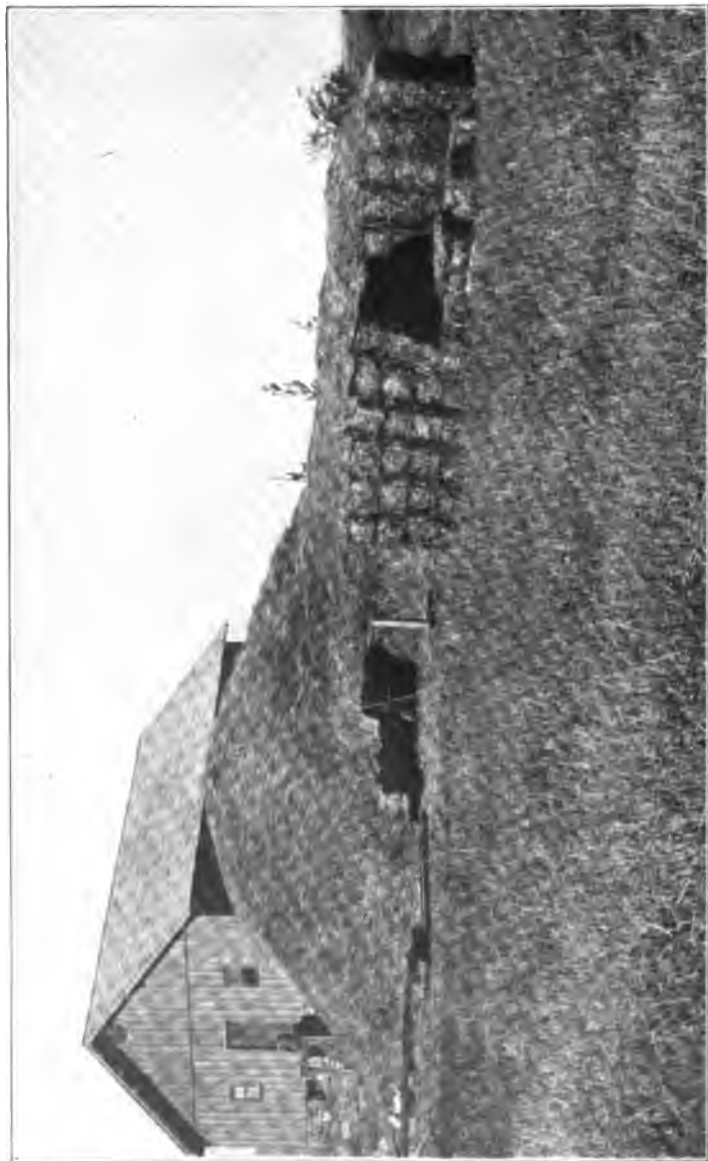
Stack of oats grown by J. A. Baca, Las Vegas.

**PLATE XI**



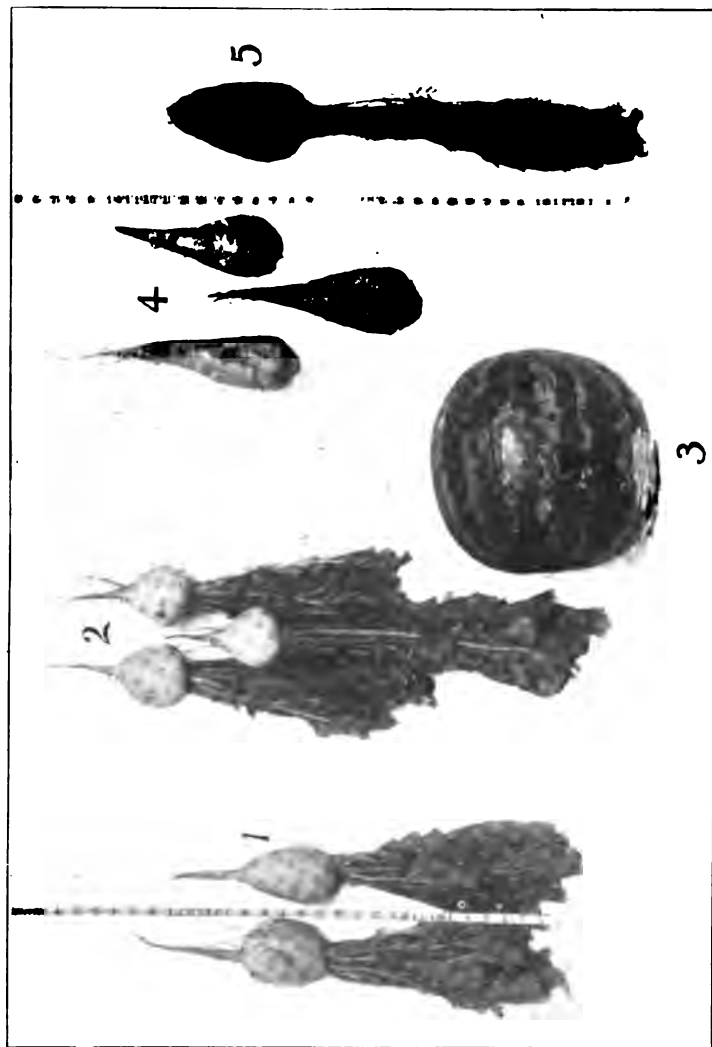
**Stacks of oats grown by S. F. Hemler, Las Vegas**

PLATE XII



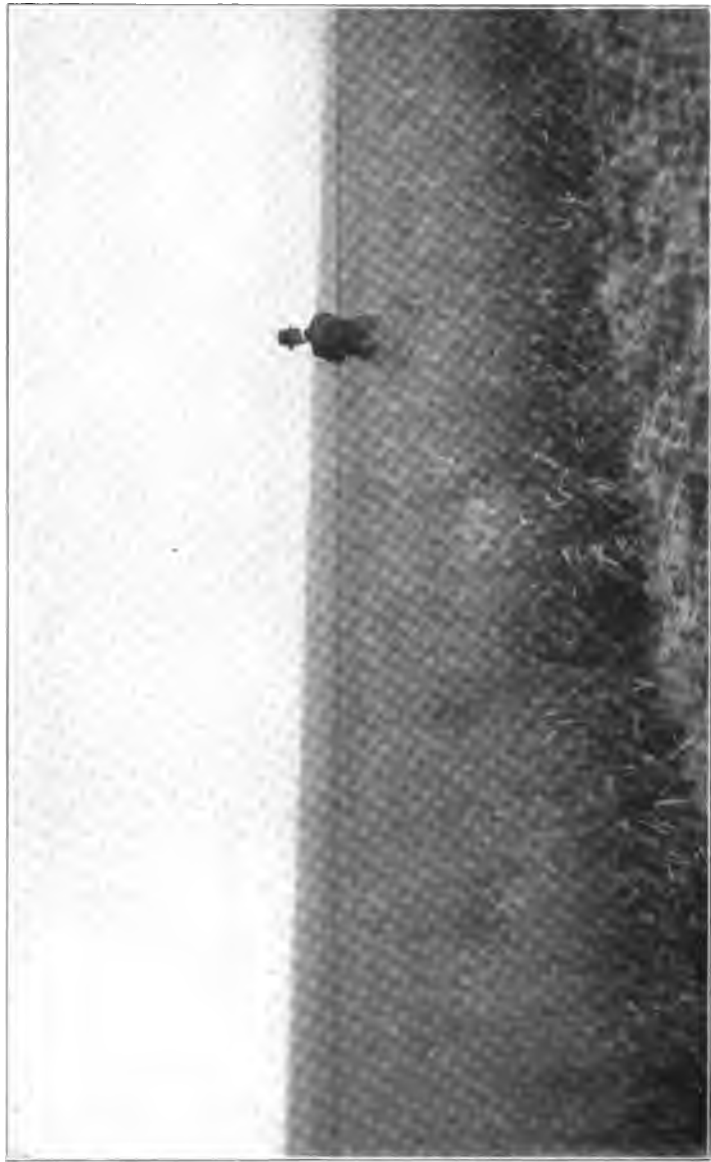
Straw stack and baled straw from wheat and oat crop grown by J. Thornhill, Las Vegas.

PLATE IX



1. Turnips, J. Thornhill, Las Vegas. 2. Turnips, T. T. Turner, Las Vegas. 3. Water-melon, J. M. Martinez, Chaperito. 4. Sugarbeets, Francisco G. Gonzales, Las Vegas. 5. Carrot, Francisco G. Gonzales, Las Vegas.

**PLATE XIV**



**Field of oats on Campbell Dry Farm, Las Vegas.**

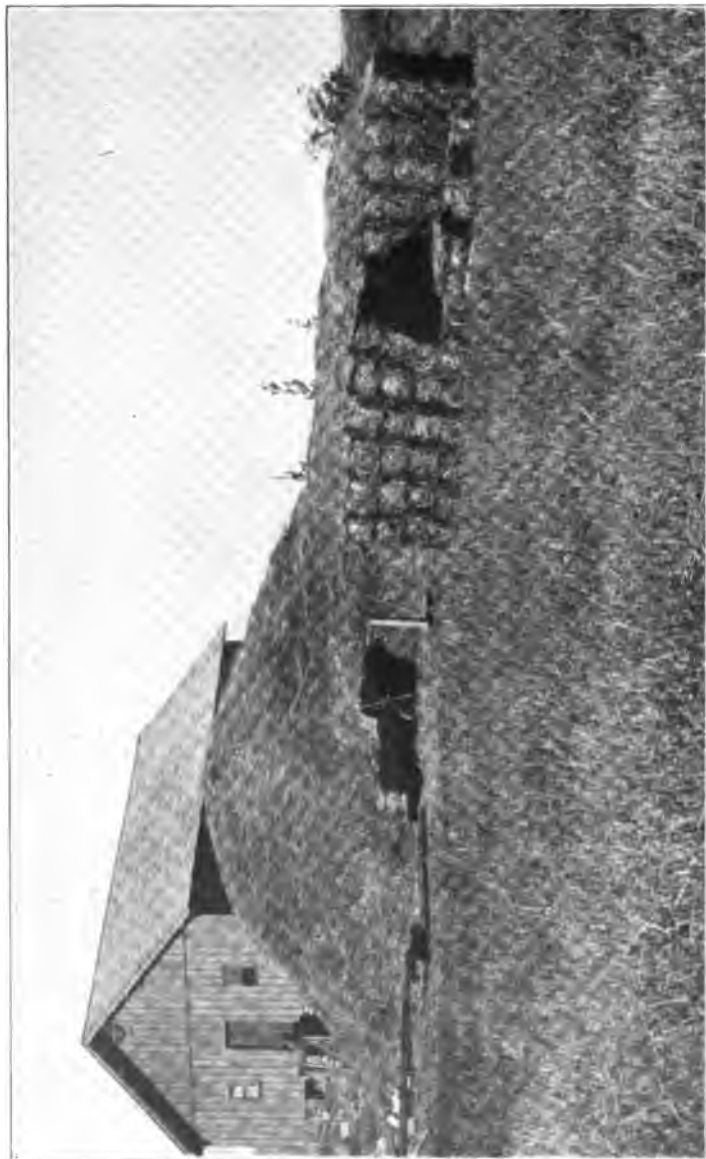


**PLATE XV**



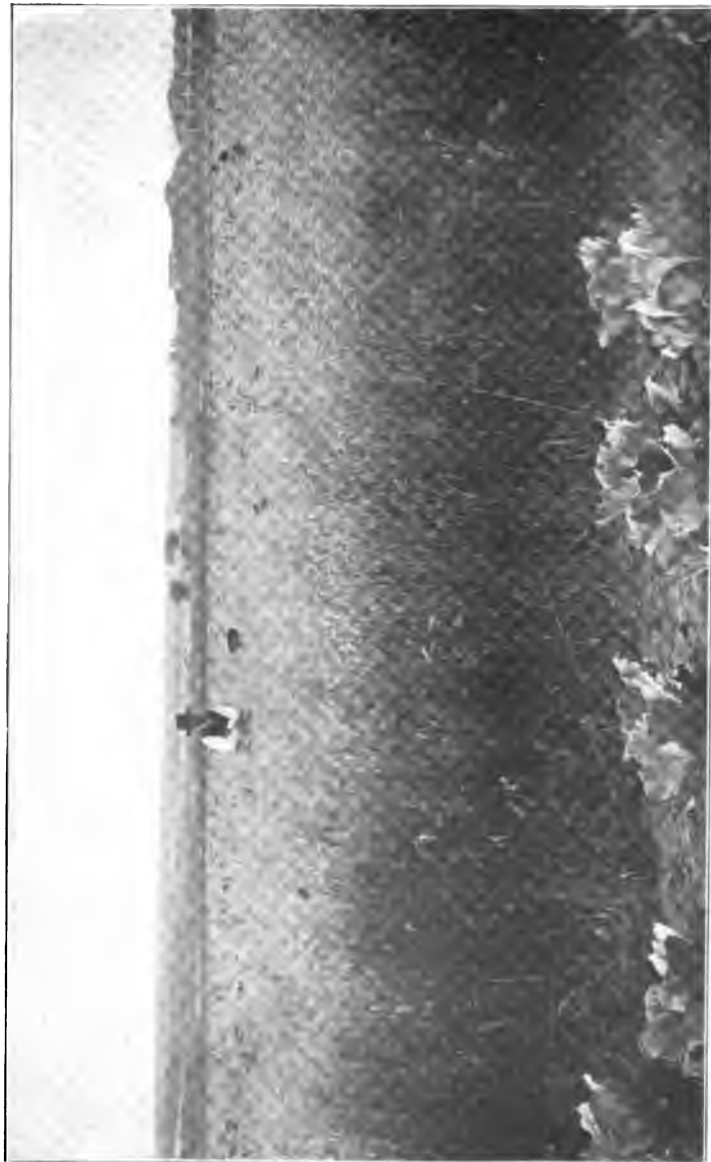
**Field of oats grown by J. A. Baca, Las Vegas.**

PLATE XII



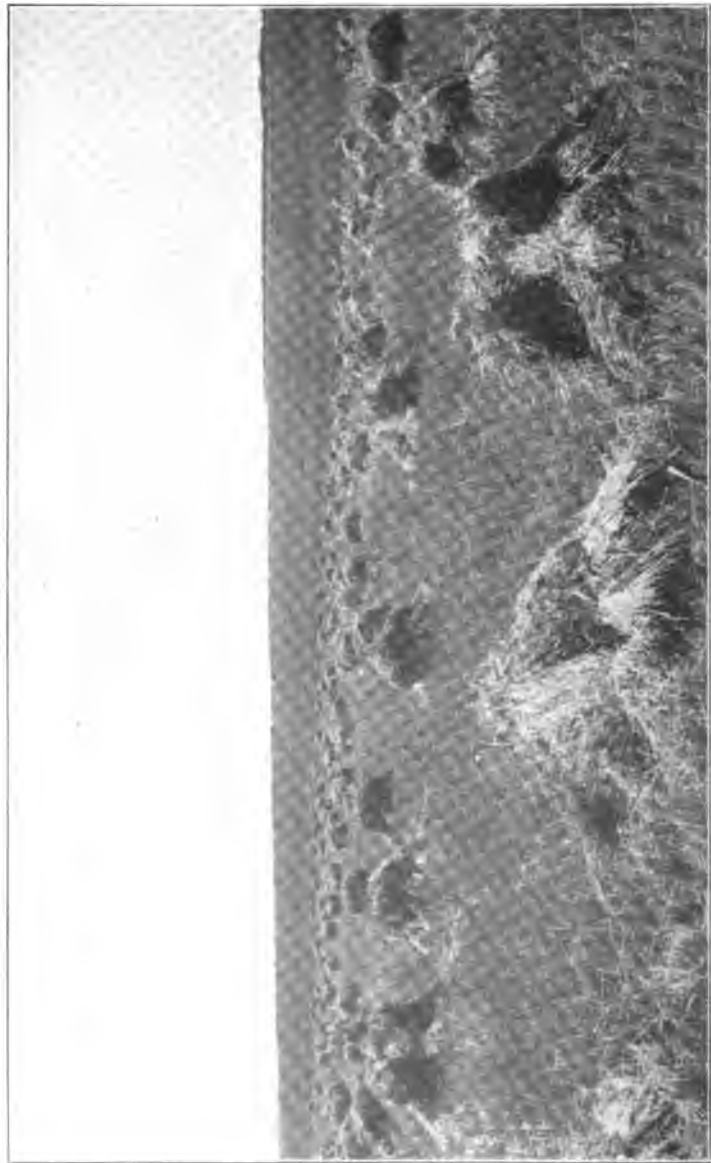
Straw stack and baled straw from wheat and oat crop grown by J. Thornhill, Las Vegas.

FLATE XVII



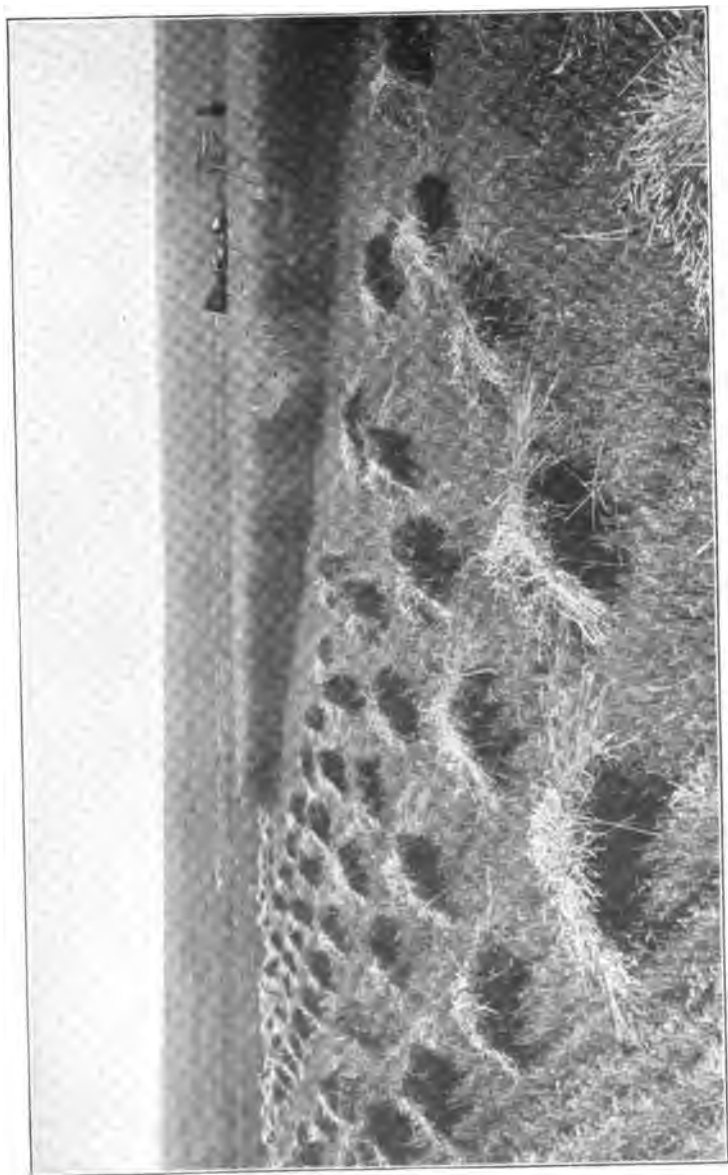
Field of oats grown by W. H. Comstock, Las Vegas.

PLATE XVIII



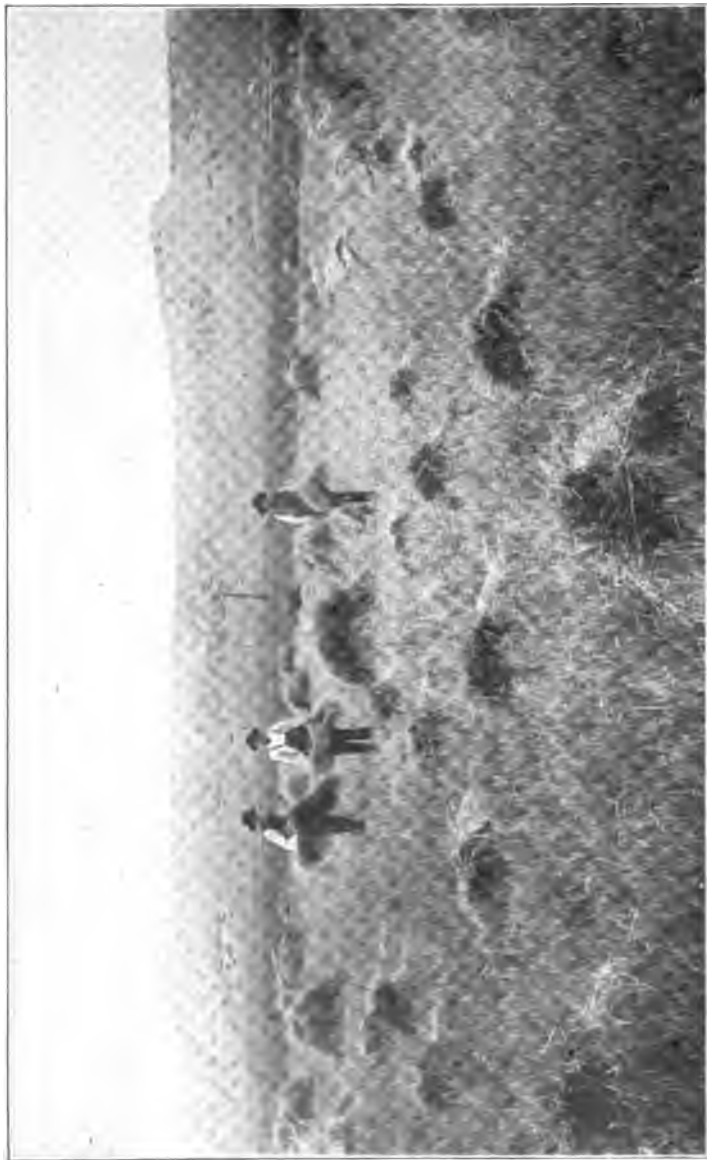
Field of spelt grown by W. H. Comstock, Las Vegas.

PLATE XIX



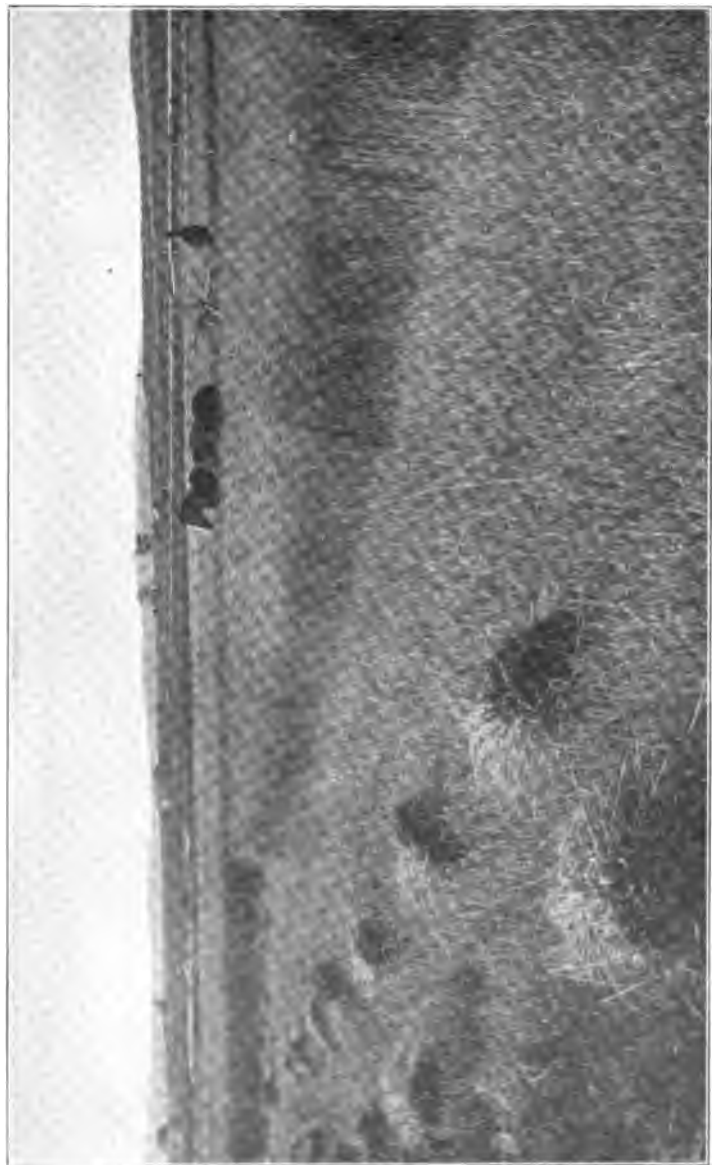
Field of wheat grown by W. H. Comstock, Las Vegas

PLATE XVI



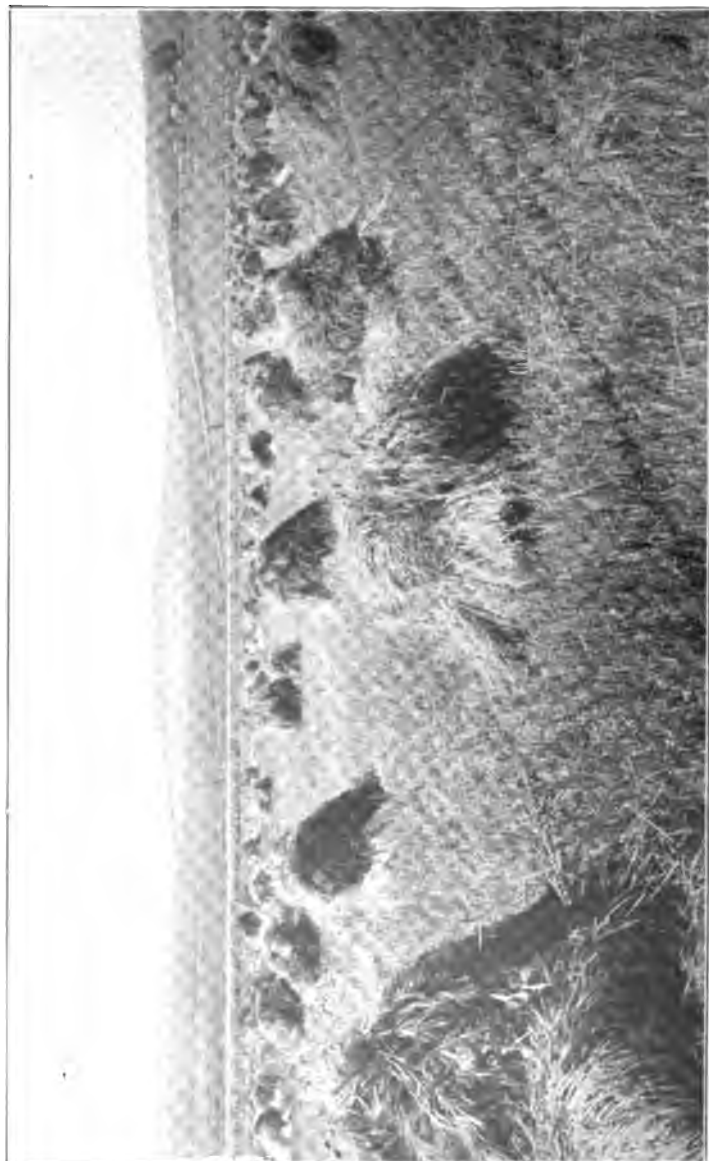
Field of speltz grown by W. H. Comstock, Las Vegas.

PLATE XXI



Field of wheat grown by W. H Comstock Las Vegas.

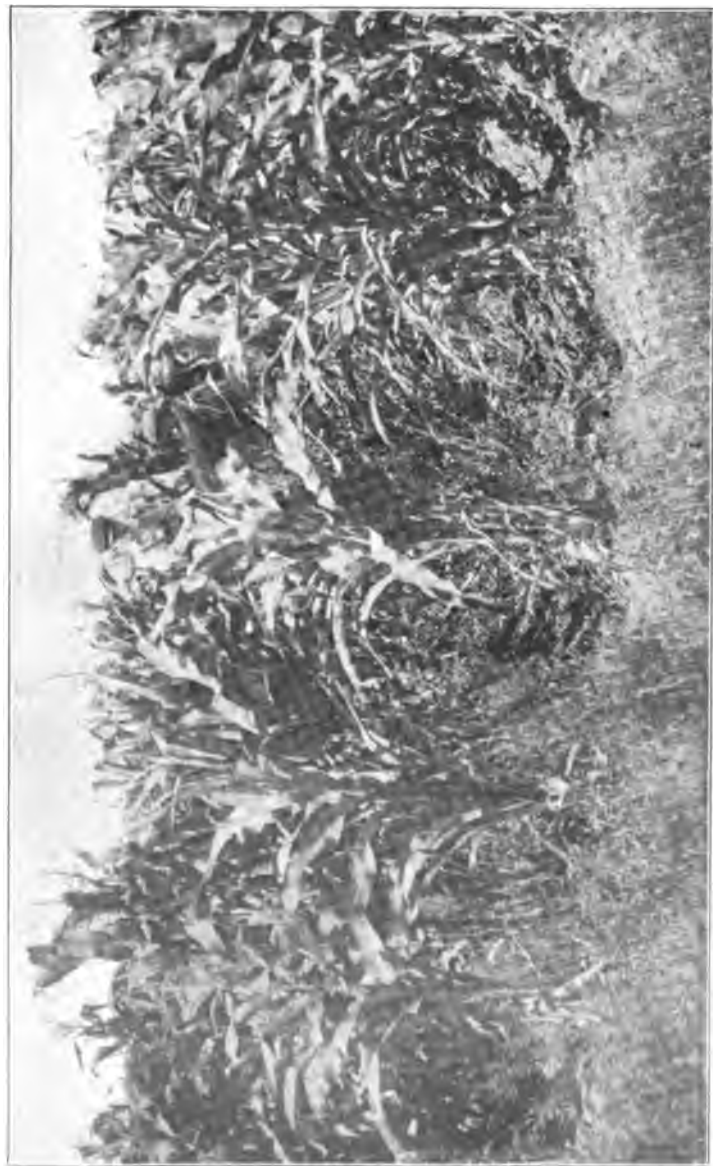
PLATE XXII



Field of wheat grown by W. H. Comstock, Las Vegas.

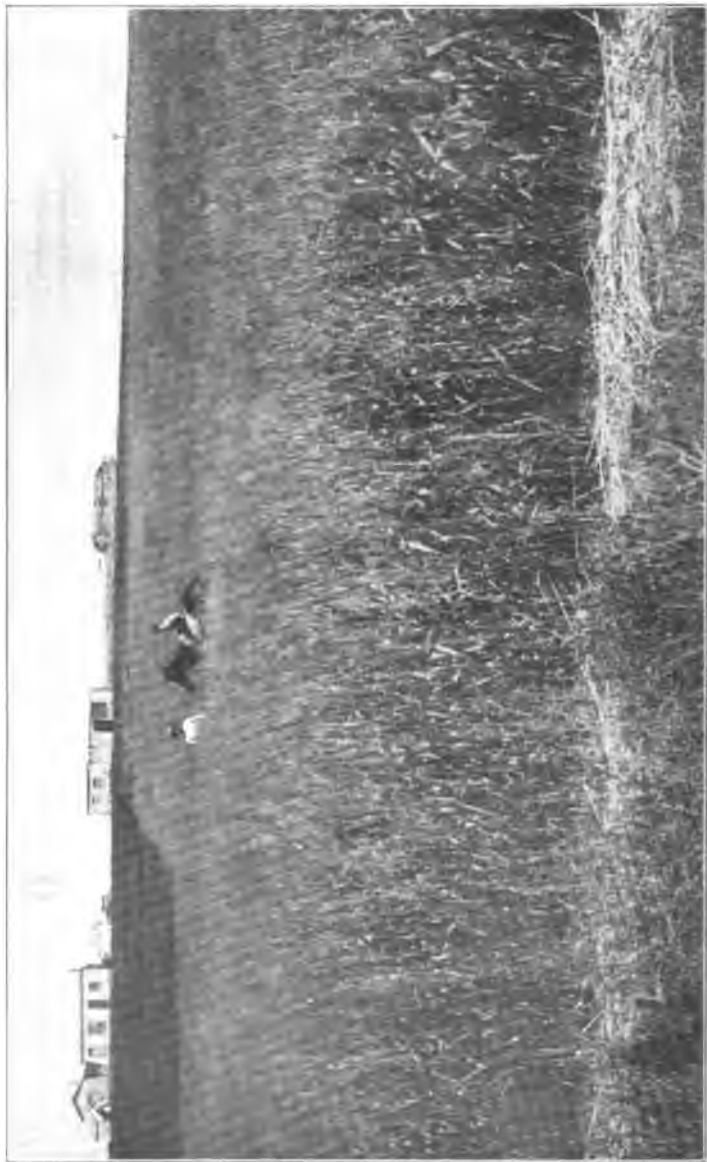


PLATE XXIII



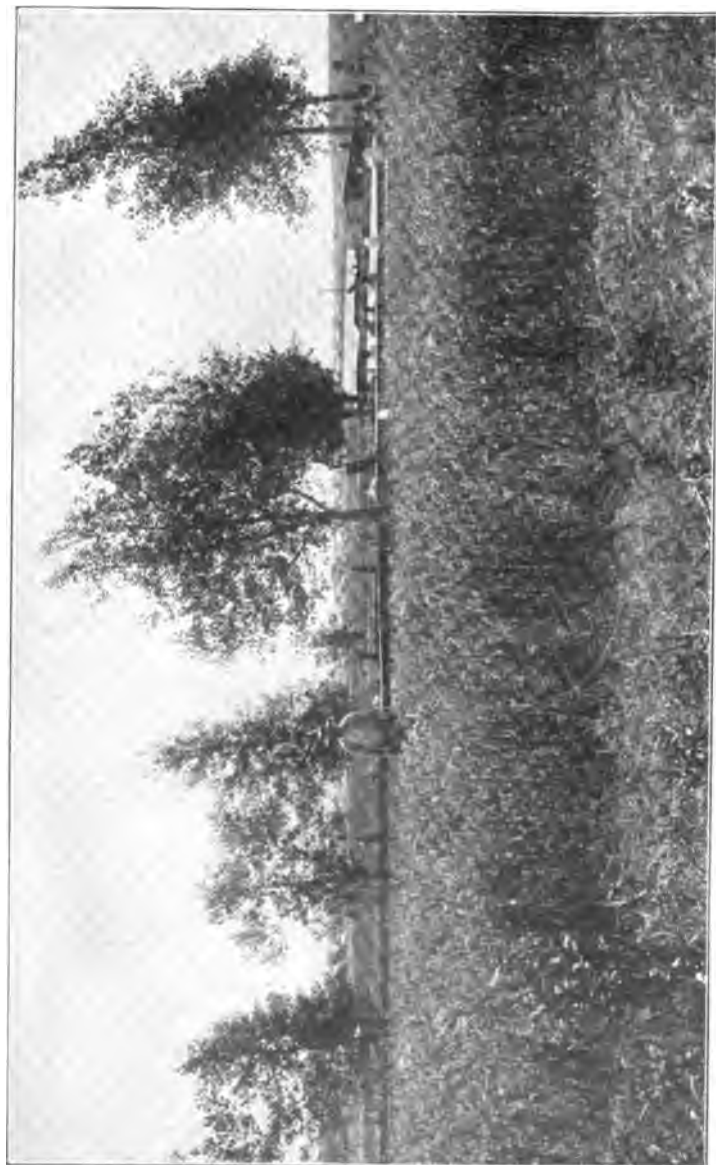
Field of corn grown by Dr. M. M. Milligan, Las Vegas.

PLATE XXIV



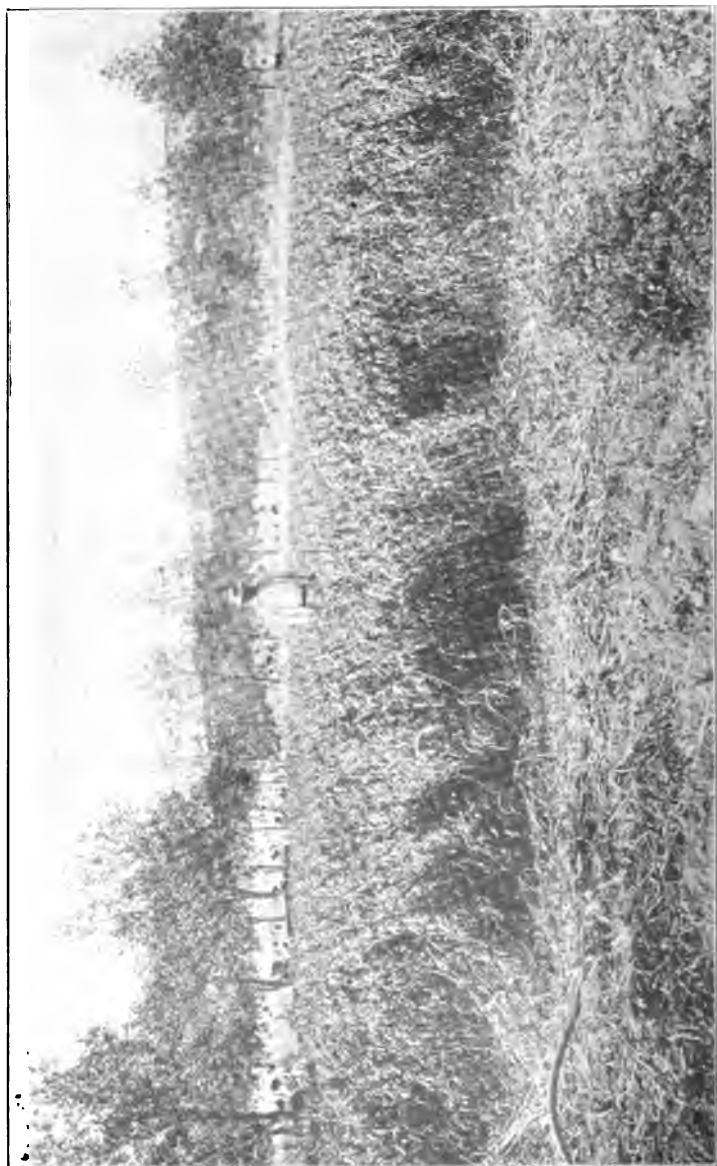
Field of wheat grown by Dr. M. M. Milligan, Las Vegas.

PLATE XXV



Field of barley grown by G. W. Ward, Las Vegas.

PLATE XXVI



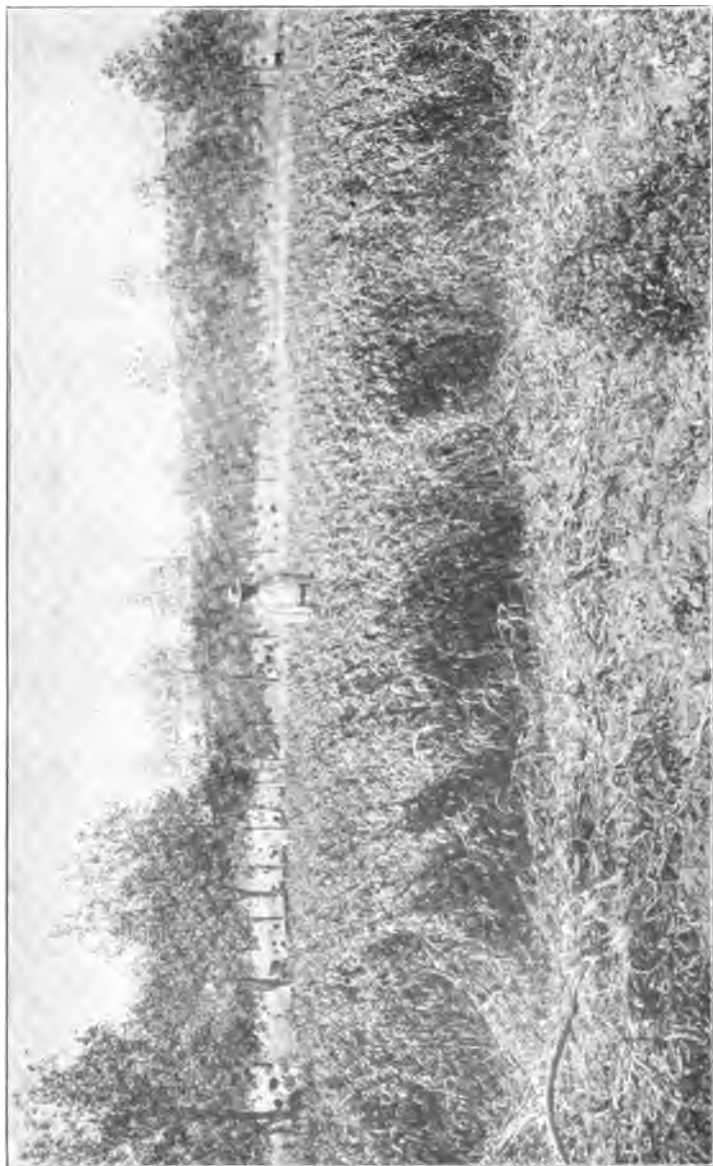
Field of millet grown by G. W. Ward, Las Vegas.

PLATE XXVII



Field of alfalfa grown by G. W. Ward, Las Vegas.

PLATE XXVI



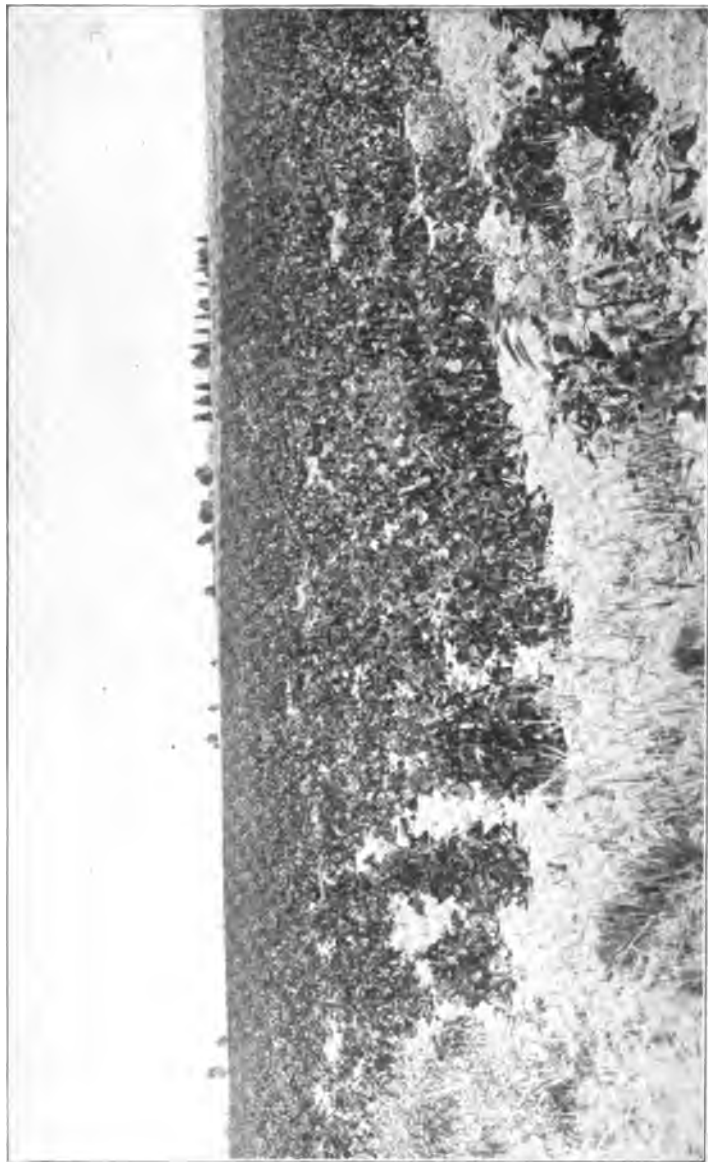
Field of millet grown by G. W. Ward, Las Vegas.

PLATE XXVII



Field of alfalfa grown by G. W. Ward, Las Vegas.

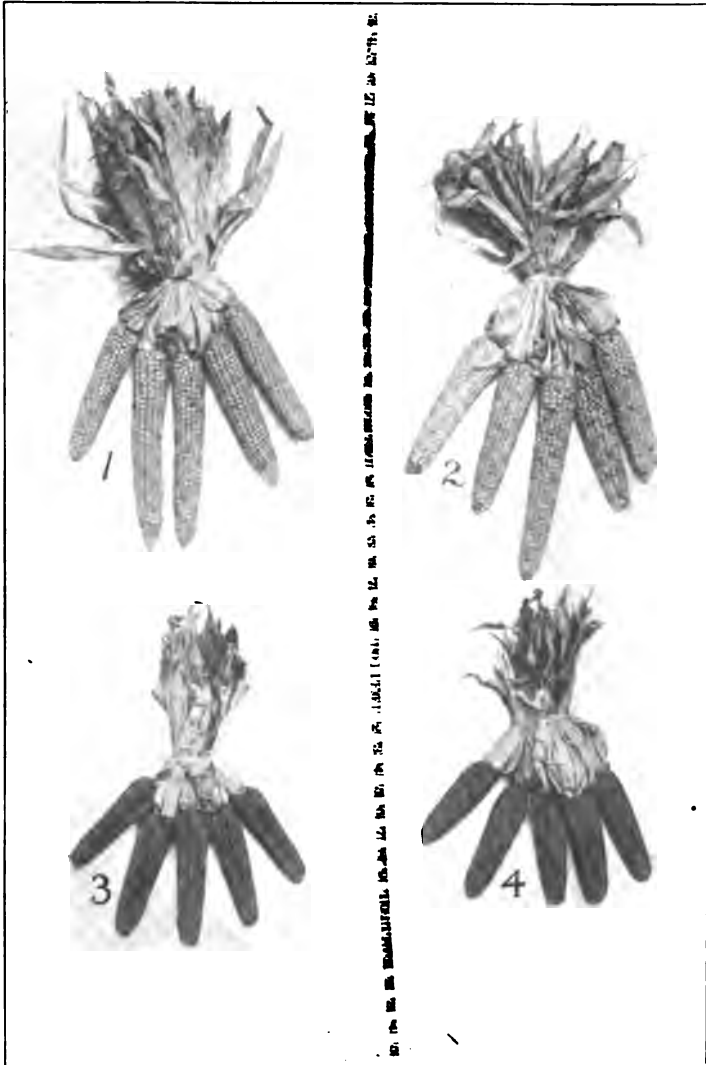
PLATE XXVIII



Field of beans grown by G. W. Ward, Las Vegas.

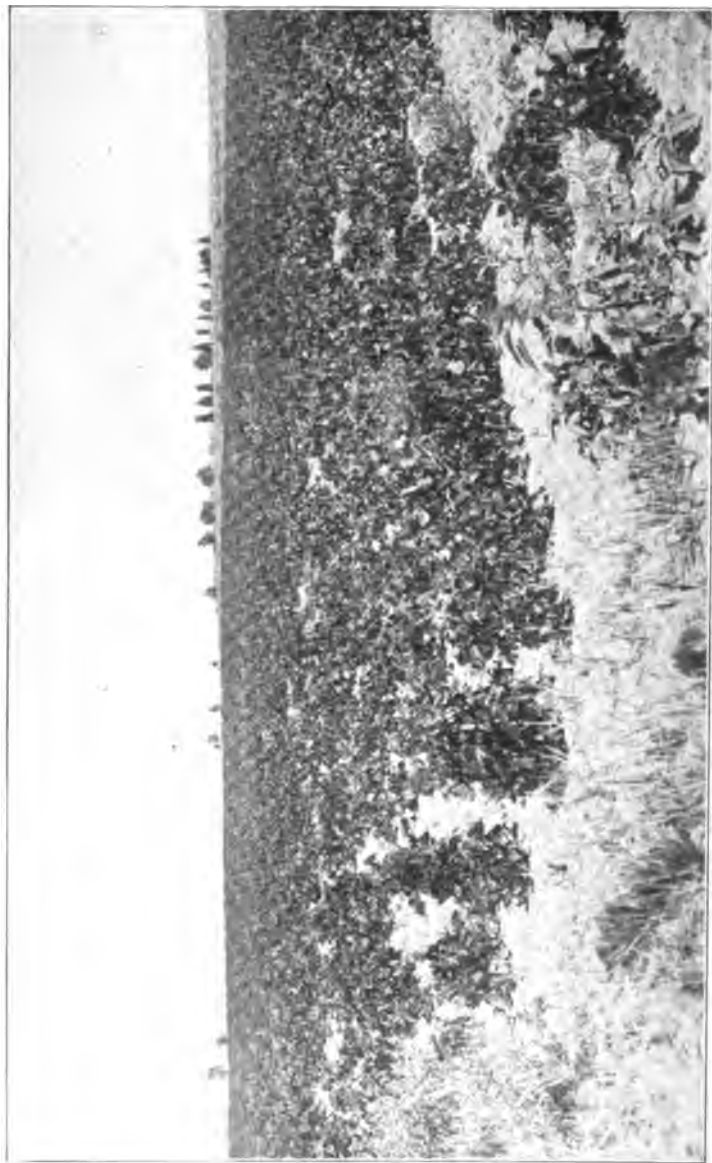


PLATE XXIX

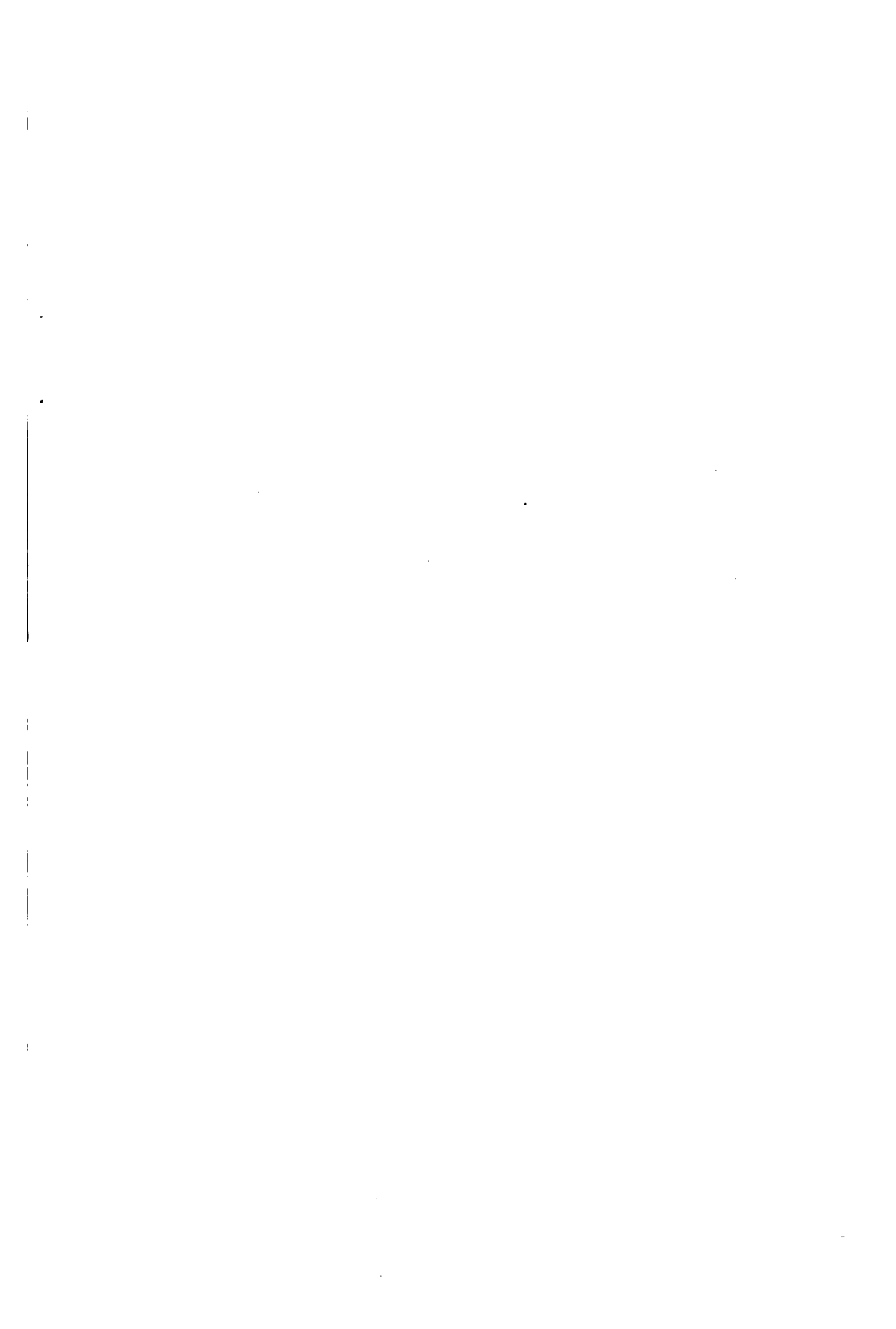


Corn and pop corn grown by J. Thornhill, Las Vegas.

PLATE XXVIII



Field of beans grown by G. W. Ward, Las Vegas.



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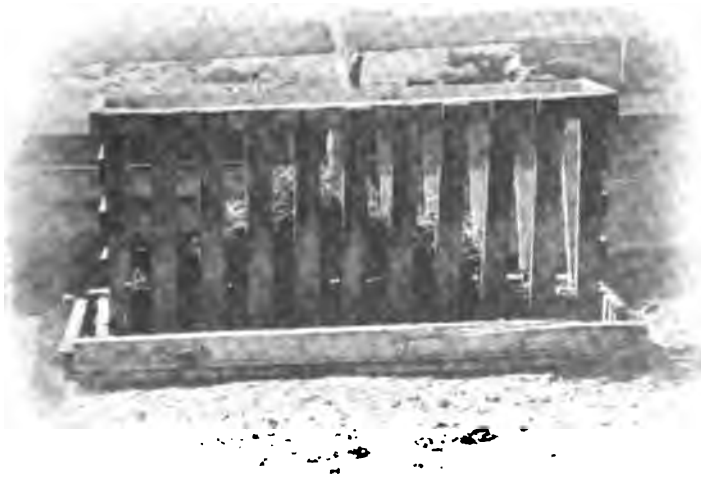
**BULLETIN NO. 62**

FEBRUARY, 1907.

**New Mexico College of Agriculture and Mechanic Arts**

**AGRICULTURAL EXPERIMENT STATION**

**AGRICULTURAL COLLEGE, N. M.**



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**PIG FEEDING**

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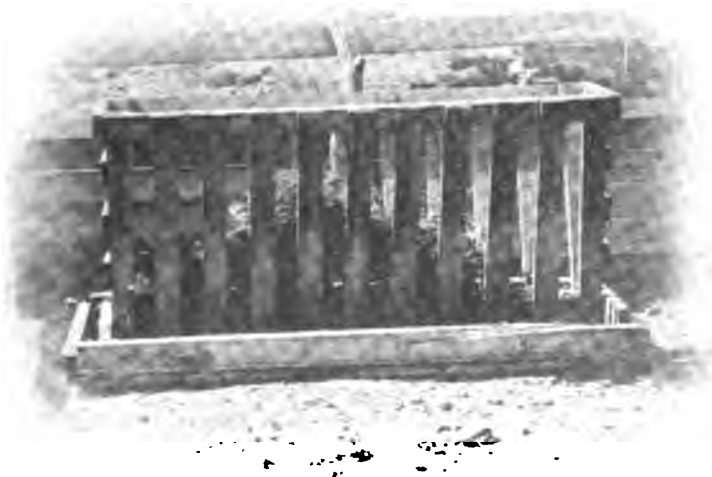
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## **SUMMARY AND CONCLUSIONS**

1. Hog raising in New Mexico is an undeveloped industry, although the conditions are very favorable in many sections.

2. Alfalfa, the leading crop in New Mexico at the present time, forms an excellent pig feed when combined with grain.

3. Alfalfa fed alone is a very poor food for fattening pigs.

4. In order to prevent undue waste when feeding alfalfa to pigs, the hay should be fed in a slatted rack placed in a flat bottomed trough. The spaces between the slats should not exceed  $2\frac{1}{2}$  inches and the trough should extend at least 18 inches beyond the rack in every direction. The coarse stems left by the pigs may be fed to stock cattle.

5. The lot of pigs which received a ration composed of nearly equal parts of alfalfa hay and corn, made greater gains and larger profits (Alfalfa hay at \$7.00 per ton) than either the lot that received a ration composed of nearly three parts of corn to one of alfalfa hay, or the lot that received a ration composed of practically two parts of alfalfa hay to one of corn.

6. The largest return per ton for the alfalfa hay, after paying for the corn consumed, was made by the lot that received the largest proportion of corn in the ration. Furthermore, the return per ton for the alfalfa hay decreased with the decrease in the proportion of corn in the ration.

## INTRODUCTION

Hog raising as an industry is in its infancy in New Mexico. While many farmers own from one to half-a-dozen hogs, those hogs are raised principally for the purpose of replenishing the family larder. The number of farmers that raise hogs, either for sale on the local markets or for shipment, are comparatively few. But, like many another phase of agricultural undertaking in this western country, hog raising properly speaking has been seldom tried, few men having given the industry serious attention or protracted effort. It should be noted, however, that the results obtained by the few who have gone into the business and prosecuted it seriously, point most decidedly in the direction of success. Evidently there is something very attractive about the work of hog raising in New Mexico if no other reason can be found why some men devote their whole time and a thousand acre irrigated farm to the industry and never seem to become weary in so doing. In fact, from the results obtained from feeding experiments on the Station farm and from information gained from hog raisers generally in the Territory, we are led to believe that this industry will become one of no mean importance. As the completion of new irrigation projects add other considerable areas to the irrigable lands of the Territory, feeds of all kinds will become more plentiful, and consequently, a strong and increasing demand will be felt for ways and means for disposing of these products. Probably no better way can be suggested for marketing farm products than to feed them to live stock upon the farm. Hogs are eminently fitted to turn into a profitable product certain classes of feeds commonly grown upon the farm. Corn, kafir corn, dourrha, milo maize, wheat, barley, rye, alfalfa, most kinds of grass, roots of all kinds, fruits and vegetables going to waste, etc., may be used either for growing or for fattening hogs. If cattle are being fattened on a ration composed partly of grain a great saving can be effected by allowing a number of hogs to follow them, thus making practically a clear gain so far as

the hogs are concerned. In the corn belt, where cattle are fed on a large scale, most feeders, if they come out even on the steers, are satisfied with the profits on the hogs that follow them.

## **THE EXPERIMENT**

### **Purpose of the Experiment**

The investigation was undertaken in order to answer the following questions:

1. What is the best proportion of alfalfa hay to corn to form a ration for feeding pigs?
2. Will alfalfa hay alone form a good and profitable ration for feeding pigs?

### **Feeding Pens**

**Feeding Pens.** The feeding pens for the pigs were 16 feet wide and 32 feet long.

**Feeding Racks.** The feeding racks consisted of a V-shaped frame 5 feet long, 3 feet high, and 1.5 feet wide at the top. (See cover page.) The frames of these racks were made of 2-inch by 4-inch pine lumber, and the sides were made with 1-inch by 4-inch slats placed two and one-half inches apart. This rack was then set in a trough two feet wide at the bottom, two and one-half feet wide at the top and four inches deep, made of 2-inch by 6-inch pine lumber.

**Weighing.** The weights were all made on a pair of ordinary wagon scales which were located near the feeding pens. A chute connected the pens with the scales.

**Water.** Good water, which was kept before the pigs all the time, was drawn from a storage tank.

**Waste.** The hay not consumed, which consisted principally of course stems, was weighed and deducted from the amount given. These stems were clean and were relished by stock cattle. No account was taken of the food thrown out of the troughs and trampled under foot, and therefore, it is included with the amount consumed.

**Labor.** No charge is made for the labor in feeding.

### **Class of Pigs**

The experiment was made with twenty-eight head of pigs

purchased from farmers in the Mesilla valley. The pigs were bought during the months of June and July, 1904. They were of no particular breeding, but were what would be called a common lot of pigs.

#### Prices Paid and Received

The price paid was  $3\frac{1}{2}$  cents per pound, live weight. The pigs were in good condition when sold and they brought  $6\frac{1}{2}$  cents per pound, dressed weight.

#### Division

The pigs were divided into four lots of seven pigs each, as nearly equal in weight and quality as possible. Each lot was weighed at the beginning and once every two weeks thereafter to the end of the test. The weighing was done at nine o'clock a. m., after feeding grain and hay but before watering.

#### Feeds

The alfalfa hay fed was purchased in the Mesilla valley at \$7.00 per ton baled and delivered. The corn cost \$1.33 per hundred delivered at the farm.

Each lot of pigs was offered a ration composed of alfalfa hay and corn in definite proportion. Owing to the fact that the coarser stems of the alfalfa were refused by the pigs the proportion of alfalfa hay to corn actually consumed was somewhat different from the proportion offered. The following table shows the proportion between the alfalfa hay and the corn in the ration offered, and consumed by each lot:

Quantity of Feed Consumed

| No. of Lot | Feed offered          |      | Feed consumed         |      |
|------------|-----------------------|------|-----------------------|------|
|            | Parts alfalfa to corn |      | Parts alfalfa to corn |      |
|            | Alfalfa               | Corn | Alfalfa               | Corn |
| 1          | 1                     | 3    | 1                     | 3.26 |
| 2          | 1                     | 1    | 1                     | 1.56 |
| 3          | 3                     | 1    | 2.02                  | 1    |
| 4          | 1                     | 0    | 1                     | 0    |

### The Feeding Period

The test was begun December 20, 1904, and continued for 73 days, ending March 3, 1905.

#### Tables

Tables I, II, III, IV, V and VI show the amount of food consumed and the net profit on each lot, with the cost of the pigs figured at \$2.50, \$3.00 and \$3.50 per hundred pounds live weight, and with alfalfa hay reckoned at the cost of production baled and stored and at cost in the stack. In each instance Lot II gave the largest net profit.

Table VII shows the amount of alfalfa hay eaten, amount of corn eaten, total feed consumed, average daily roughage per head, average roughage per month, and nutritive ratio.

Table VIII shows the weight at the beginning of the test, the weight at the end of the test, the total gain, the average gain per head, the average daily gain per head, the average daily gain per 1000 pounds live weight, the pounds of food required to make one pound gain, and the cost of one pound gain. In nearly every instance Lot II, which was fed one part of alfalfa hay to 1.56 parts of shelled corn by weight, gave the best returns, although Lot I, which was fed one part alfalfa hay to 3.26 parts shelled corn by weight gave nearly as good results. Lot III, which was fed one part corn to 2.02 parts alfalfa hay by weight, made only about half the gain in weight as did Lots I and II; and Lot IV, which received only alfalfa hay, gained about one-fifth as much as did Lots I and II. Lot IV, during the second test when fed one part alfalfa hay to 1.2 parts shelled corn by weight, made only average daily gains. These weights show that the nutritive ratio should be somewhere between 1:6.9 and 1:7.9 for the best results.

Table IX shows the comparison, by lots, between the rations; total pounds gained; average gain per head; average daily gain per head; average daily gain per 1000 pounds live weight; pounds roughage to make one pound gain; cost of 100 pounds gain with alfalfa hay figured at \$7.00, \$3.50 and \$2.50 per ton; return per ton for alfalfa hay; return per acre

for alfalfa hay; cost of hogs per head; selling price of hogs per head; cost of food per head with alfalfa hay figured at \$7.00, \$3.50 and \$2.50 per ton; profit per head with alfalfa hay figured at \$7.00, \$3.50 and \$2.50 per ton; and average per cent dressed weight. In nearly every instance Lot II which received a ration of 1 part of alfalfa to 1.56 parts of corn by weight gave the best returns. It may be of interest to note that the cost of producing 100 pounds gain increased as the amount of corn fed increased.

Table X shows the return per ton for the alfalfa hay fed. All the lots that received a ration of corn and alfalfa hay gave good returns for the hay fed, ranging from \$24.48 to \$34.68 per ton.

Table XI shows the weight and gains by periods of two weeks.

Table 1—Financial Statement

Lot I

|  | Alfalfa hay<br>baled at \$7.00<br>per ton and<br>corn at \$1.33<br>per cwt. | Alfalfa hay<br>baled at \$3.50<br>per ton and<br>corn at \$1.33<br>per cwt. | Alfalfa hay<br>in stack at<br>\$2.50 per ton<br>and corn at<br>\$1.33 per cwt. |
|--|-----------------------------------------------------------------------------|-----------------------------------------------------------------------------|--------------------------------------------------------------------------------|
|--|-----------------------------------------------------------------------------|-----------------------------------------------------------------------------|--------------------------------------------------------------------------------|

Showing the profit, pigs costing \$2.50 per hundred

|                                                           | Dr.     | Cr.     | Dr.     | Cr.     | Dr.     | Cr.     |
|-----------------------------------------------------------|---------|---------|---------|---------|---------|---------|
| By 7 pigs, 791.21 pounds dressed weight<br>@ \$6.75 ..... |         | \$53.41 |         | \$53.41 |         | \$53.41 |
| To 7 pigs, 501½ pounds live weight @<br>\$2.50 .....      | \$12.53 |         | \$12.53 |         | \$12.53 |         |
| To 590 pounds alfalfa hay .....                           | 2.07    |         | 1.04    |         | .74     |         |
| To 1927 pounds corn .....                                 | 25.63   | 40.23   | 25.63   | 39.20   | 25.63   | 38.90   |
| Profit .....                                              |         | 13.10   |         | 14.21   |         | 14.51   |

Showing the profit, pigs costing \$3.00 per hundred

| By 7 pigs, 791.21 pounds dressed weight<br>@ \$6.75 ..... |       | 53.41 |       | 53.41 |       | 53.41 |
|-----------------------------------------------------------|-------|-------|-------|-------|-------|-------|
| To 7 pigs, 501½ pounds live weight @<br>\$3.00 .....      | 15.04 |       | 15.04 |       | 15.04 |       |
| To 590 pounds alfalfa hay .....                           | 2.07  |       | 1.04  |       | .74   |       |
| To 1927 pounds corn .....                                 | 25.63 | 42.74 | 25.63 | 41.71 | 25.63 | 41.41 |
| Profit .....                                              |       | 10.07 |       | 11.70 |       | 12.00 |

Showing the profit, pigs costing \$3.50 per hundred

| By 7 pigs, 791.21 pounds dressed weight<br>@ \$6.75 ..... |       | 53.41 |       | 53.41 |       | 53.41 |
|-----------------------------------------------------------|-------|-------|-------|-------|-------|-------|
| To 7 pigs, 501½ pounds live weight @<br>\$3.50 .....      | 17.55 |       | 17.55 |       | 17.55 |       |
| To 590 pounds alfalfa hay .....                           | 2.07  |       | 1.04  |       | .74   |       |
| To 1927 pounds corn .....                                 | 25.63 | 45.25 | 25.63 | 44.22 | 25.63 | 43.92 |
| Profit .....                                              |       | 8.10  |       | 9.10  |       | 9.40  |

## PIG FEEDING

Table II—Financial Statement

Lot II

|                                                          |                                                                             |         |                                                                              |         |                                                                                |         |
|----------------------------------------------------------|-----------------------------------------------------------------------------|---------|------------------------------------------------------------------------------|---------|--------------------------------------------------------------------------------|---------|
|                                                          | Alfalfa hay<br>baled at \$7.00<br>per ton and<br>corn at \$1.33<br>per cwt. |         | Alfalfa hay<br>baled at \$3.50,<br>per ton and<br>corn at \$1.33<br>per cwt. |         | Alfalfa hay<br>in stack at<br>\$2.50 per ton<br>and corn at<br>\$1.33 per cwt. |         |
| Showing the profit, pigs costing \$2.50 per hundred      |                                                                             |         |                                                                              |         |                                                                                |         |
|                                                          | Dr.                                                                         | Cr.     | Dr.                                                                          | Cr.     | Dr.                                                                            | Cr.     |
| By 7 pigs, 805.44 pounds dressed weight<br>@ \$6.75..... |                                                                             | \$54.37 |                                                                              | \$54.37 |                                                                                | \$54.37 |
| To 7 pigs, 501½ pounds live weight<br>@ \$2.50.....      | \$12.53                                                                     |         | \$12.53                                                                      |         | \$12.53                                                                        |         |
| To 1062¼ pounds alfalfa hay.....                         | 3.72                                                                        |         | 1.86                                                                         |         | 1.33                                                                           |         |
| To 1654½ pounds corn.....                                | 22.00                                                                       | 38.25   | 22.00                                                                        | 36.39   | 22.00                                                                          | 35.86   |
| Profit.....                                              |                                                                             | 16.12   |                                                                              | 17.98   |                                                                                | 18.51   |
| Showing the profit, pigs costing \$3.00 per hundred      |                                                                             |         |                                                                              |         |                                                                                |         |
|                                                          |                                                                             |         |                                                                              |         |                                                                                |         |
| By 7 pigs, 805.44 pounds dressed weight<br>@ \$6.75..... |                                                                             | 54.37   |                                                                              | 54.37   |                                                                                | 54.37   |
| To 7 pigs, 501½ pounds live weight<br>@ \$3.00.....      | 15.04                                                                       |         | 15.04                                                                        |         | 15.04                                                                          |         |
| To 1062¼ pounds alfalfa hay.....                         | 3.72                                                                        |         | 1.86                                                                         |         | 1.33                                                                           |         |
| To 1654½ pounds corn.....                                | 22.00                                                                       | 40.76   | 22.00                                                                        | 38.90   | 22.00                                                                          | 38.87   |
| Profit.....                                              |                                                                             | 13.61   |                                                                              | 15.47   |                                                                                | 16.00   |
| Showing the profit, pigs costing \$3.50 per hundred      |                                                                             |         |                                                                              |         |                                                                                |         |
|                                                          |                                                                             |         |                                                                              |         |                                                                                |         |
| By 7 pigs, 805.44 pounds dressed weight<br>@ \$6.75..... |                                                                             | 54.37   |                                                                              | 54.37   |                                                                                | 54.37   |
| To 7 pigs, 501½ pounds live weight<br>@ \$3.50.....      | 17.55                                                                       |         | 17.55                                                                        |         | 17.55                                                                          |         |
| To 1062¼ pounds alfalfa.....                             | 3.72                                                                        |         | 1.86                                                                         |         | 1.33                                                                           |         |
| To 1654½ pounds corn.....                                | 22.00                                                                       | 43.27   | 22.00                                                                        | 41.41   | 22.00                                                                          | 40.88   |
| Profit.....                                              |                                                                             | 11.10   |                                                                              | 12.96   |                                                                                | 13.49   |



Table III—Financial Statement

Lot III

|                                                          | Alfalfa hay<br>baled at \$7.00<br>per ton and<br>corn at \$1.33<br>per cwt. |         | Alfalfa hay<br>baled at \$8.50<br>per ton and<br>corn at \$1.33<br>per cwt. |         | Alfalfa hay<br>in stack at<br>\$2.50 per ton<br>and corn at<br>\$1.33 per cwt. |         |
|----------------------------------------------------------|-----------------------------------------------------------------------------|---------|-----------------------------------------------------------------------------|---------|--------------------------------------------------------------------------------|---------|
| Showing the profit, pigs costing \$2.50 per hundred      |                                                                             |         |                                                                             |         |                                                                                |         |
|                                                          | Dr.                                                                         | Cr.     | Dr.                                                                         | Cr.     | Dr.                                                                            | Cr.     |
| By 7 pigs, 557.23 pounds dressed weight<br>@ \$6.75..... |                                                                             | \$37.61 |                                                                             | \$37.61 |                                                                                | \$37.61 |
| To 7 pigs, 489½ pounds live weight<br>@ \$3.50.....      | \$12.23                                                                     |         | \$12.23                                                                     |         | \$12.23                                                                        |         |
| To 1338 pounds alfalfa hay.....                          | 4.48                                                                        |         | 2.34                                                                        |         | 1.67                                                                           |         |
| To 661.83 pounds corn.....                               | 8.80                                                                        | 25.71   | 8.80                                                                        | 23.37   | 8.80                                                                           | 22.70   |
| Profit.....                                              |                                                                             | 11.80   |                                                                             | 14.24   |                                                                                | 14.81   |
| Showing the profit, pigs costing \$3.00 per hundred      |                                                                             |         |                                                                             |         |                                                                                |         |
|                                                          |                                                                             |         |                                                                             |         |                                                                                |         |
| By 7 pigs, 557.23 pounds dressed weight<br>@ \$6.75..... |                                                                             | \$37.61 |                                                                             | \$37.61 |                                                                                | \$37.61 |
| To 7 pigs, 489½ pounds live weight<br>@ \$3.00.....      | \$14.68                                                                     |         | \$14.68                                                                     |         | \$14.68                                                                        |         |
| To 1338 pounds alfalfa hay.....                          | 4.68                                                                        |         | 2.34                                                                        |         | 1.67                                                                           |         |
| To 661.83 pounds corn.....                               | 8.80                                                                        | 28.16   | 8.80                                                                        | 25.82   | 8.80                                                                           | 25.15   |
| Profit.....                                              |                                                                             | 8.45    |                                                                             | 11.79   |                                                                                | 12.48   |
| Showing the profit, pigs costing \$3.50 per hundred      |                                                                             |         |                                                                             |         |                                                                                |         |
|                                                          |                                                                             |         |                                                                             |         |                                                                                |         |
| By 7 pigs, 557.23 pounds dressed weight<br>@ \$6.75..... |                                                                             | \$37.61 |                                                                             | \$37.61 |                                                                                | \$37.61 |
| To 7 pigs, 489½ pounds live weight<br>@ \$3.50.....      | \$17.13                                                                     |         | \$17.13                                                                     |         | \$17.13                                                                        |         |
| To 1338 pounds alfalfa hay.....                          | 4.68                                                                        |         | 2.34                                                                        |         | 1.67                                                                           |         |
| To 661.83 pounds corn.....                               | 8.80                                                                        | 30.61   | 8.80                                                                        | 28.27   | 8.80                                                                           | 27.60   |
| Profit.....                                              |                                                                             | 7.00    |                                                                             | 9.34    |                                                                                | 10.01   |

## PIG FEEDING

Table IV—Financial Statement

Lot IV

|                                                           | Alfalfa hay<br>baled at \$7.00<br>per ton. |          | Alfalfa hay<br>baled at \$3.50<br>per ton. |          | Alfalfa hay in<br>stack at \$2.50<br>per ton. |          |
|-----------------------------------------------------------|--------------------------------------------|----------|--------------------------------------------|----------|-----------------------------------------------|----------|
| Showing the profit, pigs costing \$2.50 per hundred       |                                            |          |                                            |          |                                               |          |
|                                                           | Dr.                                        | Cr.      | Dr.                                        | Cr.      | Dr.                                           | Cr.      |
| By 7 pigs, 311.85 pounds dressed weight<br>@ \$6.75 ..... |                                            | \$ 21.05 |                                            | \$ 21.05 |                                               | \$ 21.05 |
| To 7 pigs, 482 pounds live weight @<br>\$2.50 .....       | \$ 12.05                                   |          | \$ 12.05                                   |          | \$ 12.05                                      |          |
| To 1697 pounds alfalfa hay .....                          | 5.94                                       | 17.99    | 2.97                                       | 15.02    | 2.12                                          | 14.17    |
| Profit .....                                              |                                            | 3.06     |                                            | 6.03     |                                               | 6.88     |
| Showing the profit, pigs costing \$3.00 per hundred       |                                            |          |                                            |          |                                               |          |
|                                                           |                                            |          |                                            |          |                                               |          |
| By 7 pigs, 311.85 pounds dressed weight<br>@ \$6.75 ..... |                                            | \$ 21.05 |                                            | \$ 21.05 |                                               | \$ 21.05 |
| To 7 pigs, 282 pounds live weight @<br>\$3.00 .....       | \$ 14.46                                   |          | \$ 14.46                                   |          | \$ 14.46                                      |          |
| To 1697 pounds alfalfa hay .....                          | 5.94                                       | 20.40    | 2.97                                       | 17.43    | 2.12                                          | 16.58    |
| Profit .....                                              |                                            | .65      |                                            | 3.62     |                                               | 4.47     |
| Showing the profit, pigs costing \$3.50 per hundred       |                                            |          |                                            |          |                                               |          |
|                                                           |                                            |          |                                            |          |                                               |          |
| By 7 pigs, 311.85 pounds dressed weight<br>@ \$6.75 ..... |                                            | \$ 21.05 |                                            | \$ 21.05 |                                               | \$ 21.05 |
| To 7 pigs, 482 pounds live weight @<br>\$3.50 .....       | \$ 16.87                                   |          | \$ 16.87                                   |          | \$ 16.87                                      |          |
| To 1697 pounds alfalfa hay .....                          | 5.94                                       | 22.81    | 2.97                                       | \$ 19.84 | 2.12                                          | 18.99    |
| Profit .....                                              |                                            | 1.78*    |                                            | 1.21     |                                               | 2.96     |

\* Loss.

**Table V—Financial Statement—Second Test**

Lot IV

|                                                       |                                                                             |         |                                                                            |         |                                                                                |         |
|-------------------------------------------------------|-----------------------------------------------------------------------------|---------|----------------------------------------------------------------------------|---------|--------------------------------------------------------------------------------|---------|
|                                                       | Alfalfa hay<br>baled at \$7.00<br>per ton and<br>corn at \$1.33<br>per cwt. |         | Alfalfa hay<br>baled at \$1.50<br>per ton and<br>corn at \$1.33<br>per cwt |         | Alfalfa hay<br>in stack at<br>\$2.50 per ton<br>and corn at<br>\$1.33 per cwt. |         |
| Showing the profit, pigs costing \$2.50 per hundred   |                                                                             |         |                                                                            |         |                                                                                |         |
| By 7 pigs, 533 pounds dressed weight @<br>\$6.75..... | Dr.                                                                         | Cr.     | Dr.                                                                        | Cr.     | Dr.                                                                            | Cr.     |
|                                                       |                                                                             | \$35.98 |                                                                            | \$35.98 |                                                                                | \$35.98 |
| To 7 pigs, 570.5 pounds live weight @ \$2.50          | \$14.26                                                                     |         | \$14.26                                                                    |         | \$14.26                                                                        |         |
| To 567.5 pounds alfalfa hay.....                      | 1.99                                                                        |         | .99                                                                        |         | .70                                                                            |         |
| To 681 pounds corn.....                               | 9.06                                                                        | 25.31   | 9.06                                                                       | 24.31   | 9.06                                                                           | 24.02   |
| Profit.....                                           |                                                                             | 10.87   |                                                                            | 11.87   |                                                                                | 11.98   |
| Showing the profit, pigs costing \$3.00 per hundred   |                                                                             |         |                                                                            |         |                                                                                |         |
| By 7 pigs, 533 pounds dressed weight @<br>\$6.75..... |                                                                             | 35.98   |                                                                            | 35.98   |                                                                                | 35.98   |
| To 7 pigs, 570.5 pounds live weight @ \$3.00          | 17.11                                                                       |         | 17.11                                                                      |         | 17.11                                                                          |         |
| To 567.5 pounds alfalfa hay.....                      | 1.99                                                                        |         | .99                                                                        |         | .70                                                                            |         |
| To 681 pounds corn.....                               | 9.06                                                                        | 28.16   | 9.06                                                                       | 27.16   | 9.06                                                                           | 26.87   |
| Profit.....                                           |                                                                             | 7.82    |                                                                            | 8.82    |                                                                                | 9.11    |
| Showing the profit, pigs costing \$3.50 per hundred   |                                                                             |         |                                                                            |         |                                                                                |         |
| By 7 pigs, 533 pounds dressed weight @<br>\$6.75..... |                                                                             | 35.98   |                                                                            | 35.98   |                                                                                | 35.98   |
| To 7 pigs, 570.5 pounds live weight @ \$3.50          | 19.97                                                                       |         | 19.97                                                                      |         | 19.97                                                                          |         |
| To 567.5 pounds alfalfa hay.....                      | 1.99                                                                        |         | .99                                                                        |         | .70                                                                            |         |
| To 681 pounds corn.....                               | 9.06                                                                        | 31.02   | 9.06                                                                       | 25.74   | 9.06                                                                           | 25.50   |
| Profit.....                                           |                                                                             | 4.25    |                                                                            | 5.10    |                                                                                | 5.34    |

Table VI—Financial Statement—1st and 2nd Tests Combined

Lot IV

|                                                       |                                                                             |         |                                                                             |         |                                                                                |         |
|-------------------------------------------------------|-----------------------------------------------------------------------------|---------|-----------------------------------------------------------------------------|---------|--------------------------------------------------------------------------------|---------|
|                                                       | Alfalfa hay<br>baled at \$7.00<br>per ton and<br>corn at \$1.33<br>per cwt. |         | Alfalfa hay<br>baled at \$3.50<br>per ton and<br>corn at \$1.33<br>per cwt. |         | Alfalfa hay in<br>stack at \$2.50<br>per ton and<br>corn at \$1.33<br>per cwt. |         |
| Showing the profit, pigs costing \$2.50 per hundred   |                                                                             |         |                                                                             |         |                                                                                |         |
| By 7 pigs, 533 pounds dressed weight<br>@ \$6.75..... | Dr.                                                                         | Cr.     | Dr.                                                                         | Cr.     | Dr.                                                                            | Cr.     |
|                                                       |                                                                             | \$35.98 |                                                                             | \$35.98 |                                                                                | \$35.98 |
| To 7 pigs, 482 pounds live weight @ \$2.50.....       | \$12.05                                                                     |         | \$12.05                                                                     |         | \$12.05                                                                        |         |
| To 2264.5 pounds alfalfa hay.....                     | 7.92                                                                        |         | 3.96                                                                        |         | 2.83                                                                           |         |
| To 681 pounds corn.....                               | 9.06                                                                        | 29.03   | 9.06                                                                        | 25.01   | 9.06                                                                           | 23.94   |
| Profit.....                                           |                                                                             | 6.95    |                                                                             | 10.97   |                                                                                | 12.04   |
| Showing the profit, pigs costing \$3.00 per hundred   |                                                                             |         |                                                                             |         |                                                                                |         |
| By 7 pigs, 533 pounds dressed weight<br>@ \$6.75..... |                                                                             | 35.98   |                                                                             | 35.98   |                                                                                | 35.98   |
| To 7 pigs, 482 pounds live weight @ \$3.00.....       | 14.46                                                                       |         | 14.46                                                                       |         | 14.46                                                                          |         |
| To 2264.5 pounds alfalfa hay.....                     | 7.92                                                                        |         | 3.96                                                                        |         | 2.83                                                                           |         |
| To 681 pounds corn.....                               | 9.06                                                                        | 31.44   | 9.06                                                                        | 27.48   | 9.06                                                                           | 26.35   |
| Profit.....                                           |                                                                             | 4.54    |                                                                             | 8.50    |                                                                                | 9.83    |
| Showing the profit, pigs costing \$3.50 per hundred   |                                                                             |         |                                                                             |         |                                                                                |         |
| By 7 pigs, 533 pounds dressed weight<br>@ \$6.75..... |                                                                             | 35.98   |                                                                             | 35.98   |                                                                                | 35.98   |
| To 7 pigs, 482 pounds live weight @ \$3.50.....       | 16.87                                                                       |         | 16.87                                                                       |         | 16.87                                                                          |         |
| To 2264.5 pounds alfalfa hay.....                     | 7.92                                                                        |         | 3.96                                                                        |         | 2.83                                                                           |         |
| To 681 pounds corn.....                               | 9.06                                                                        | 38.85   | 9.06                                                                        | 29.89   | 9.06                                                                           | 28.76   |
| Profit.....                                           |                                                                             | 2.13    |                                                                             | 6.08    |                                                                                | 7.22    |

Table VII—Feeds Consumed

|                                                    | Lot I<br>Pounds | Lot II<br>Pounds | Lot III<br>Pounds | Lot IV             |                    |                                            |
|----------------------------------------------------|-----------------|------------------|-------------------|--------------------|--------------------|--------------------------------------------|
|                                                    |                 |                  |                   | 1st Test<br>Pounds | 2nd Test<br>Pounds | 1st and 2nd<br>Tests<br>Combined<br>Pounds |
| Total alfalfa.....                                 | 590             | 1062.25          | 1339              | 1697               | 567.5              | 2264.5                                     |
| Total corn.....                                    | 1927            | 1654.50          | 661.83            |                    | 681.               | 681.00                                     |
| Total feed.....                                    | 2517            | 2716.75          | 1999.83           | 1697               | 1248.5             | 2945.5                                     |
| Average daily<br>roughage per<br>head (73 days)... | 1.15            | 2.08             | 2.62              | 3.32               | 2.62*              | 3.11**                                     |
| Average rough-<br>age per month<br>per head.....   | 34.62           | 62.34            | 78.55             | 99.60              | 81.06              | 94.59                                      |
| Nutritive Ratio....                                | 1:7.9           | 1:6.9            | 1:5.4             | 1:3.8              | 1:6.5              | 1:4.9                                      |

\*81 days. \*\*104 days.

Table VIII—Weights and Gains

|                                                               | Lot I<br>Pounds | Lot II<br>Pounds | Lot III<br>Pounds | Lot IV             |                    |                                            |
|---------------------------------------------------------------|-----------------|------------------|-------------------|--------------------|--------------------|--------------------------------------------|
|                                                               |                 |                  |                   | 1st Test<br>Pounds | 2nd test<br>Pounds | 1st and 2nd<br>Tests<br>Combined<br>Pounds |
| Weight at begin-<br>ning of test....                          | 501.3           | 501.3            | 489.3             | 482                | 489                | 482                                        |
| Weight at end of<br>test. ....                                | 1020.6          | 1022.6           | 788.3             | 590.3              | 646.6              | 764.36                                     |
| Total gain.....                                               | 519.3           | 521.3            | 299               | 108.3              | 157.6              | 272.36                                     |
| Average gain per<br>head .....                                | 74.19           | 74.48            | 42.71             | 15.48              | 26.27              | 38.91                                      |
| Average daily gain<br>per head (73 days)                      | 1.016           | 1.02             | .59               | .21                | .85*               | .374**                                     |
| Average daily<br>gain per 1,000<br>pounds live<br>weight..... | 14.19           | 14.25            | 8.37              | 3.08               | 10.40              | 3.47                                       |
| Pounds of food to<br>make one pound<br>gain .....             | 4.865           | 5.21             | 6.688             | 15.665             | 6.78               | 10.81                                      |
| Pounds of food to<br>make 100 pounds<br>gain .....            | 486.5           | 521.11           | 668.82            | 1566.50            | 678.00             | 1081.43                                    |
| Cost of one pound<br>of gain.....                             | \$ .0533        | .0493            | .0451             | .0548              | .06                | .0432                                      |
| Cost of 100 pounds<br>gain .....                              | \$ 5.33         | 4.93             | 4.51              | 5.48               | 6.00               | 6.32                                       |

\* 81 days. \*\* 104 days.

Table IX—Comparison by Lots Between the Rations

|                                                              | Lot I                                           | Lot II                                          | Lot III                                         | Lot IV                    |                                                         |                            |
|--------------------------------------------------------------|-------------------------------------------------|-------------------------------------------------|-------------------------------------------------|---------------------------|---------------------------------------------------------|----------------------------|
|                                                              | Alfalfa hay 1 part to corn 3.28 parts by weight | Alfalfa hay 1 part to corn 1.66 parts by weight | Alfalfa hay 2.02 parts to corn 1 part by weight | 1st test alfalfa hay only | 2nd test alfalfa hay 1 part to corn 1.2 parts by weight | 1st and 2nd tests combined |
| Total pounds gained.....                                     | 519.3                                           | 521.3                                           | 299.00                                          | 108.3                     | 183.8                                                   | 272.36                     |
| Average gain per (head).....                                 | 74.19                                           | 74.48                                           | 42.71                                           | 15.48                     | 26.27                                                   | 38.91                      |
| Average daily gain per head (73 days).....                   | 1.016                                           | 1.02                                            | .59                                             | .212                      | * .847                                                  | ** .374                    |
| Average daily gain per 1,000 pounds live weight.....         | 14.19                                           | 14.25                                           | 8.37                                            | 3.08                      | 10.4                                                    | 3.47                       |
| Pounds roughage to make 100 pounds gain.....                 | 113.63                                          | 203.76                                          | 447.49                                          | 1,566.50                  | 360.00                                                  | 831.43                     |
| Pounds roughage to make 1 pound gain.....                    | 1.14                                            | 2.04                                            | 4.47                                            | 15.66                     | 3.60                                                    | 8.31                       |
| Cost of 100 pounds gain (alfalfa hay @ \$7.00 per ton).....  | \$5.33                                          | \$4.93                                          | \$4.51                                          | \$5.48                    | \$6.01                                                  | \$6.32                     |
| Cost of 100 pounds gain, (alfalfa hay @ \$3.50 per ton)..... | 5.14                                            | 4.58                                            | 3.73                                            | 2.74                      | 5.46                                                    | 4.86                       |
| Cost of 100 pounds gain, (alfalfa hay @ \$2.50 per ton)..... | 5.08                                            | 4.48                                            | 3.50                                            | 1.96                      | 5.31                                                    | 4.45                       |
| Return per ton for alfalfa hay..                             | 34.68                                           | 27.91                                           | 17.46                                           | 4.93                      | 24.48                                                   | 8.86                       |
| Return per acre for alfalfa hay***                           | 104.04                                          | 13.73                                           | 52.34                                           | 14.79                     | 73.44                                                   | 26.58                      |
| Cost of bogs per head.....                                   | 2.51                                            | 2.51                                            | 2.45                                            | 2.41                      | 2.45                                                    | 2.41                       |
| Selling price per head.....                                  | 7.63                                            | 7.78                                            | 5.37                                            | 3.01                      | 5.14                                                    | 5.14                       |
| Cost of food per head (alfalfa hay @ \$7.00 per ton)...      | 3.96                                            | 3.67                                            | 1.93                                            | .85                       | 1.58                                                    | 2.42                       |

Table IX—Comparison By Lots Between the Rations

|                                                                     | Lot I                                                 | Lot II                                                | Lot III                                               | Lot IV                       |                                                               |                               |
|---------------------------------------------------------------------|-------------------------------------------------------|-------------------------------------------------------|-------------------------------------------------------|------------------------------|---------------------------------------------------------------|-------------------------------|
|                                                                     | Alfalfa hay 1 part<br>to corn 3.26 parts<br>by weight | Alfalfa hay 1 part<br>to corn 1.56 parts<br>by weight | Alfalfa hay 2.02<br>parts to corn 1<br>part by weight | 1st test alfalfa hay<br>only | 2nd test alfalfa hay<br>1 part to corn 1.2<br>parts by weight | 1st and 2nd tests<br>combined |
| Profit per head<br>(alfalfa hay @<br>\$7.00 per ton...              | 1.16                                                  | 1.60                                                  | .99                                                   | -.25                         | .71                                                           | .31                           |
| Cost of food per<br>head (alfalfa hay<br>@ \$3.50 per ton)          | 3.81                                                  | 3.41                                                  | 1.59                                                  | .42                          | 1.44                                                          | 1.86                          |
| Profit per head<br>(alfalfa hay @<br>\$3.50 per ton)...             | 1.31                                                  | 1.85                                                  | 1.33                                                  | .27                          | .85                                                           | .87                           |
| Cost of food per<br>head (alfalfa<br>hay @ \$2.50 per<br>ton) ..... | 3.77                                                  | 3.33                                                  | 1.50                                                  | .30                          | 1.40                                                          | 1.70                          |
| Profit per head<br>(alfalfa hay @<br>\$2.50 per ton)...             | 1.36                                                  | 1.93                                                  | 1.46                                                  | .29                          | .89                                                           | 1.03                          |
| Average percent<br>dressed weight.                                  | 77.52                                                 | 78.76                                                 | 70.67                                                 | 52.83                        | 70.41                                                         | 71.27                         |

\* 31 days.

\*\* 104 days.

\*\*\* Yield three tons per acre.

‡Cost 3¼ cents per pound.

Table X—Return per Ton for Alfalfa Hay

| Lot I                                                 |         |                            |
|-------------------------------------------------------|---------|----------------------------|
| By 7 pigs, 791.21 pounds dressed weight @ \$6.75..... |         | \$53.41                    |
| To 7 pigs, 501.3 pounds live weight @ \$3.50.....     | \$17.55 |                            |
| To 1927 pounds corn @ \$1.33 per cwt.....             | 25.63   | 48.18                      |
| Balance to credit of alfalfa hay.....                 |         | \$10.23                    |
| Received per ton for alfalfa hay.....                 |         | \$34.00                    |
| Lot II                                                |         |                            |
| By 7 pigs, 805.44 pounds dressed weight @ \$6.75..... |         | 54.37                      |
| To 7 pigs, 501.3 pounds live weight @ \$3.50.....     | 17.55   |                            |
| To 1654.5 pounds corn @ \$1.33 per cwt.....           | 22.00   | 39.56                      |
| Balance to credit of alfalfa hay.....                 |         | 14.82                      |
| Received per ton for alfalfa hay.....                 |         | 27.91                      |
| Lot III                                               |         |                            |
| By 7 pigs, 557.33 pounds dressed weight @ \$6.75..... |         | 37.61                      |
| To 7 pigs, 499.3 pounds live weight @ \$3.50.....     | 17.13   |                            |
| To 661.83 pounds corn @ \$1.33 per cwt.....           | 8.80    | 25.98                      |
| Balance to credit of alfalfa hay.....                 |         | 11.68                      |
| Received per ton for alfalfa hay.....                 |         | 17.40                      |
| Lot IV                                                |         |                            |
| By 7 pigs, 311.85 pounds dressed weight @ \$6.75..... |         | 21.05                      |
| To 7 pigs, 482 pounds live weight @ \$3.50.....       | 16.87   | 16.87                      |
| Balance to credit of alfalfa hay.....                 |         | 4.18                       |
| Received per ton for alfalfa hay.....                 |         | 4.93                       |
| Lot IV                                                |         | 2nd test                   |
| By 7 pigs, 533 pounds dressed weight @ \$6.75.....    |         | 35.98                      |
| To 7 pigs, 570.5 pounds live weight @ \$3.50.....     | 19.97   |                            |
| To 681 pounds corn @ \$1.33.....                      | 9.06    | 29.03                      |
| Balance to credit of alfalfa hay.....                 |         | 6.96                       |
| Received per ton for alfalfa hay.....                 |         | 24.40                      |
| Lot IV                                                |         | 1st and 2nd tests combined |
| By 7 pigs, 533 pounds dressed weight @ \$6.75.....    |         | 35.98                      |
| To 7 pigs, 482 pounds live weight @ \$3.50.....       | 16.87   |                            |
| To 681 pounds corn @ \$1.33.....                      | 9.06    | 25.93                      |
| Balance to credit of alfalfa hay.....                 |         | 10.06                      |
| Received per ton for alfalfa hay.....                 |         | 8.00                       |

NOTE—One-half of the pigs in Lot IV were slaughtered at the end of the first test and the percent dressed weight determined. In both the first and second tests, for easy comparison, the figures are brought to the original bases.



Table XI—Weights and Gains by Periods of Two Weeks

|         | Lot I           |                | Lot II          |                | Lot III         |                | Lot IV          |                |                 |                |
|---------|-----------------|----------------|-----------------|----------------|-----------------|----------------|-----------------|----------------|-----------------|----------------|
|         |                 |                |                 |                |                 |                | 1st test        |                | 2nd test        |                |
|         | W'ght<br>Pounds | Gain<br>Pounds | W'ght<br>Pounds | Gain<br>Pounds | W'ght<br>Pounds | Gain<br>Pounds | W'ght<br>Pounds | Gain<br>Pounds | W'ght<br>Pounds | Gain<br>Pounds |
| Dec. 21 | 501.3           | 00             | 501.3           | 00             | 489.3           | 00             | 482             | 00             |                 |                |
| Jan. 4  | 612             | 110.6          | 612             | 110.6          | 562             | 62.6           | 512             | 30             |                 |                |
| Jan. 18 | 714             | 102            | 710             | 98             | 608             | 56             | 514             | 2              |                 |                |
| Feb. 1  | 814             | 100            | 804             | 94             | 664             | 56             | 558             | 44             |                 |                |
| Feb. 15 | 918             | 104            | 910             | 106            | 714             | 50             | 552             | 6              |                 |                |
| Mar. 1  | 1020.6          | 102.6          | 1022.6          | 112.6          | 788.3           | 74.3           | 590.3           | 32.3           |                 |                |
| Mar. 15 |                 |                |                 |                |                 |                |                 |                | 586.6           | 00             |
| Mar. 29 |                 |                |                 |                |                 |                |                 |                | 676.3           | 89.7           |
| Apr. 12 |                 |                |                 |                |                 |                |                 |                | 735             | 58.7           |

#### Diseases

The hog raising industry in New Mexico has never been seriously menaced by swine diseases. The freedom from disease is believed to be due, partly at least, to the salubrious climatic conditions, but they are likely to become more prevalent with the growth of the industry and with the increase in the number of hogs raised.

Hog cholera and swine plague, two diseases of swine which have been most destructive in the hog raising sections of the country, are almost unknown in New Mexico. Nevertheless, it is a wise precaution to prepare for their attacks, the first step of which should consist in becoming familiar with the symptoms of these diseases and the best methods for their prevention. A comprehensive discussion of hog cholera and swine plague will be found in Farmer's Bulletin No. 24 of the United States Department of Agriculture. This bulletin may be secured free by addressing the Secretary of Agriculture, Washington, D. C.

Trichinosis has been reported from certain sections in New Mexico. While trichinae is not as destructive to the hog as is cholera, yet the former is a greater menace to the health of man than the latter, for the reason that man is susceptible to the attacks of trichinae.

The following excerpt on "Trichinae in Meat" taken from

"The Care of Animals," by Nelson S. Mayo, one of highest authorities on diseases of animals in the United States, gives briefly the cause, symptoms and measures for the prevention of the disease trichinosis.

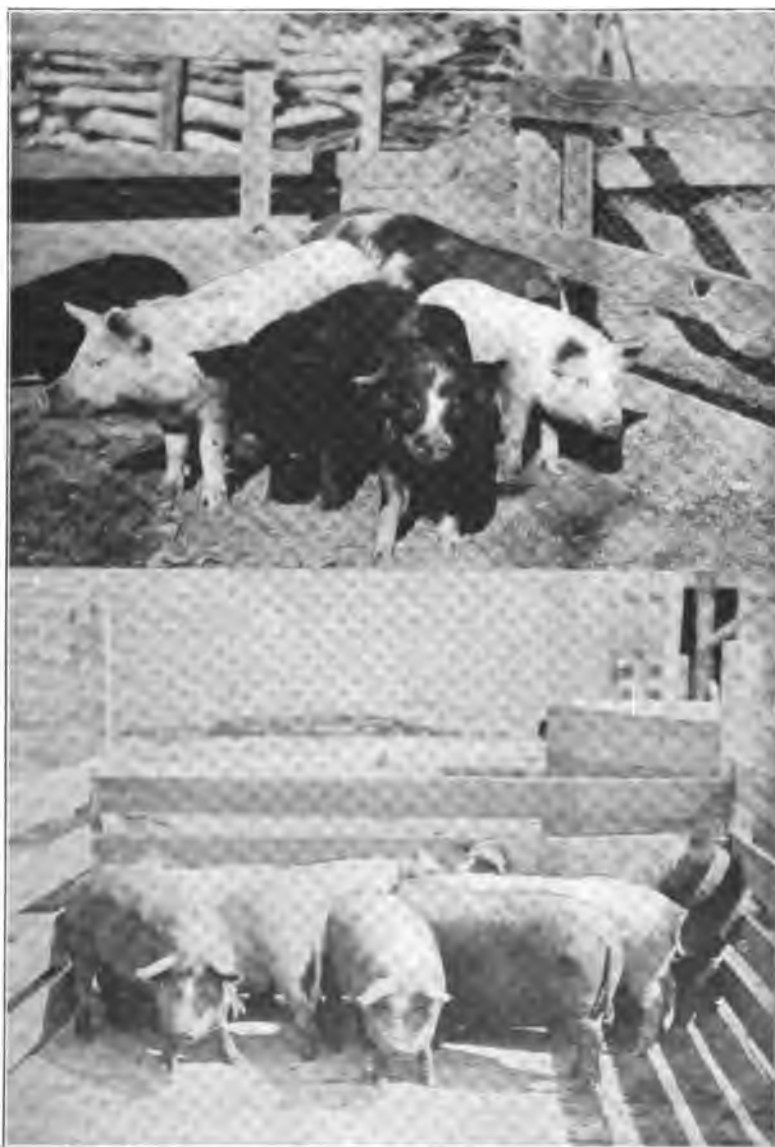
#### Trichinae in Meat

"Trichinosis is a disease especially of pigs and man, caused by the invasion of the tissues of the body by a minute round worm (*Trichina Spiralis*) that bores its way to the different parts of the body, and then becomes encysted. Man usually contracts the disease by eating infested pork that has not been thoroughly cooked. Trichinae in pork are invisible to the naked eye. When taken into the stomach, the encysted worm is liberated, develops into adult, and the females give birth to large numbers (ten to fifteen thousand) of embryo young. These young worms migrate, boring their way, or are carried by the blood and lymph, to distant parts of the body, there developing the cyst stage. When these cysts are examined under a microscope, each is found to contain the small, cylindrical embryo worm, in a coiled or spiral position, from which it takes its Latin name."

"When meat infested with trichinae is eaten, there follows, in the human subject, considerable irritation of the bowels, associated with diarrhea. This occurs in three to ten days after the meat has been eaten. During this period, the worms are multiplying in the digestive tract of the patient. Following this, there is severe soreness of the muscles, associated with fever. During this stage, the young trichinae are migrating, working their way through the tissues of the body. In general, it has been said that the symptoms of trichinosis in man are those of rheumatism, associated with typhoid fever. The disease has never been recognized by any symptoms shown by pigs. Pigs do not die of trichinosis. The worms can be found in the muscular tissue by making a microscopical examination. In examining the carcasses of pigs for trichinae, specimens of lean meat should be taken from the deeper muscles of the neck, inner face of the shoulder, 'midriff' or diaphragm, tenderloin, or the base of the tongue, as the parasites are most frequent in these regions. Estimates as to the prevalence of trichinosis in pigs varies from two to ten per cent. Pigs that are kept in unsanitary or filthy quarters and fed upon offal are more frequently diseased. There is no remedy. Pork or ham should never be eaten without a most thorough cooking."

Note—"The Care of Animals," by Nelson S. Mayo

PLATE I



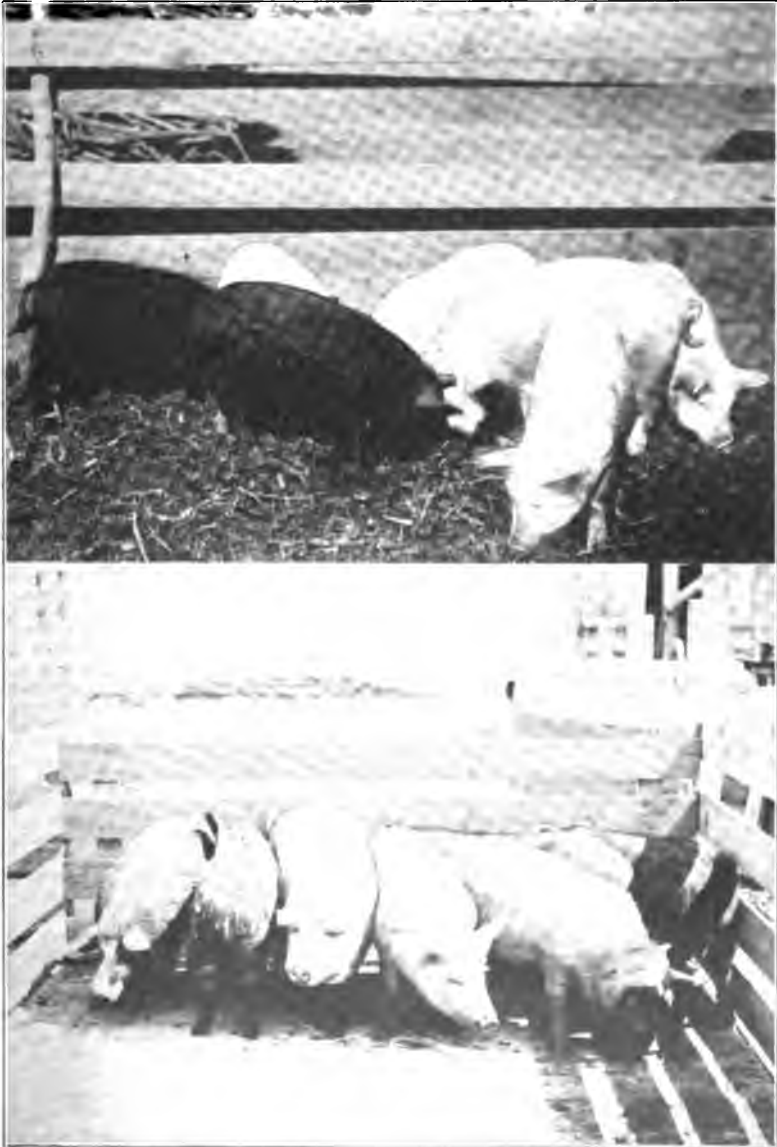
Lot I.—Consumed 1 part alfalfa hay to 3.26 parts corn by weight. The upper figure represents the lot at the beginning and the lower figure represents the lot at the ending of the test.

PLATE II



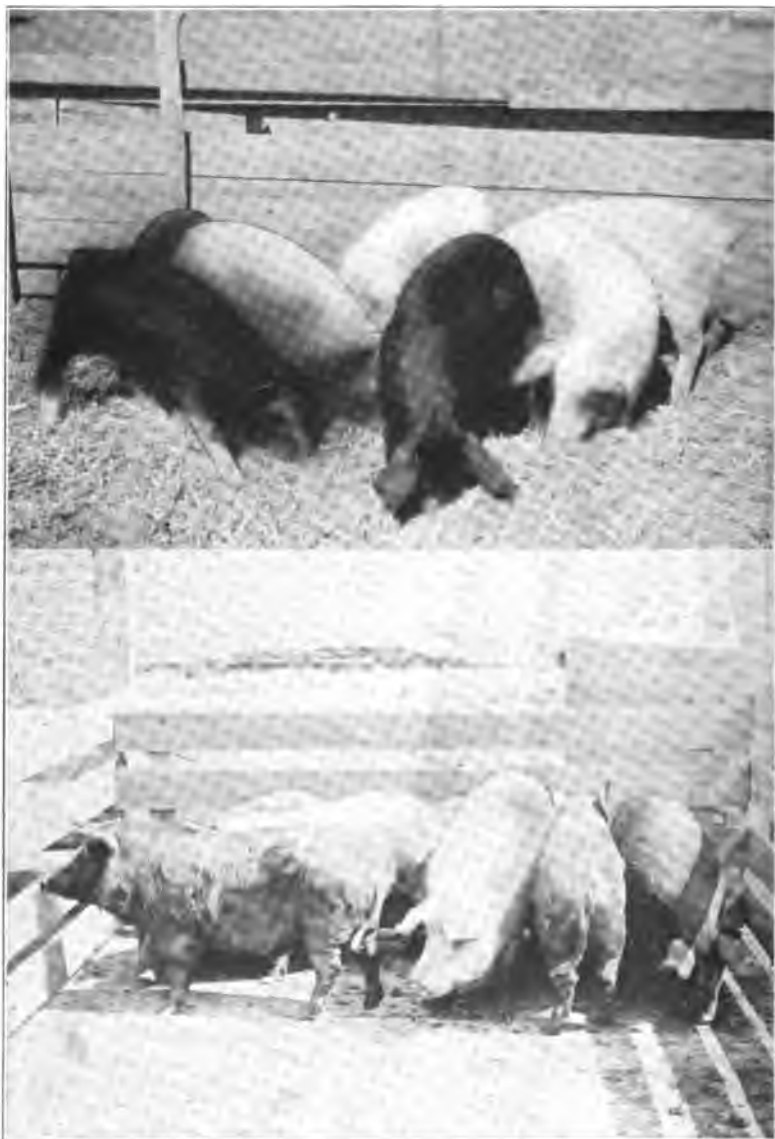
Lot II.—Consumed 1 part alfalfa hay to 1.56 parts corn by weight. The upper figure represents the lot at the beginning and the lower figure represents the lot at the end of the test.

PLATE III



Lot III.—Consumed 2.02 parts alfalfa hay to 1 part corn by weight. The upper figure represents the lot at the beginning and the lower figure represents the lot at the end of the test.

**PLATE IV**



**Lot IV.—Alfalfa hay only. The upper figure represents the lot at the beginning and the lower figure represents the lot at the end of the test.**

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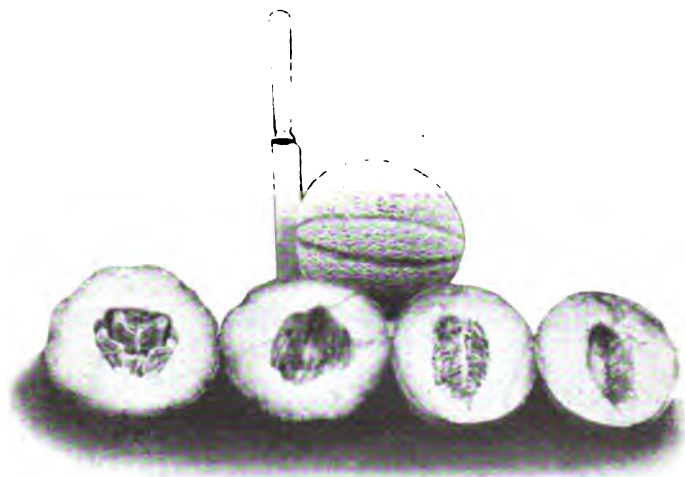
## BULLETIN NO. 63

MARCH, 1907.

New Mexico College of Agriculture and Mechanic Arts

AGRICULTURAL EXPERIMENT STATION

AGRICULTURAL COLLEGE, N. M.



Good Marketable Size Rocky Ford Cantaloupes.

# MELON CULTURE

BY

FABIÁN GARCÍA.

SANTA FE, N. M.  
NEW MEXICAN PRINTING COMPANY  
1907.

# NEW MEXICO AGRICULTURAL EXPERIMENT STATION

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and to others, as far as the editions printed will allow,  
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## **MELON CULTURE**

### **Introduction**

There have been many inquiries recently in regard to information about growing of vegetables, and the demand for such information is increasing. This is due, perhaps, more now than formerly, to the increased immigration into the Territory from other states. Although many of the people may be gardeners, the conditions and practices here are so different from that to which they have been accustomed that everything is practically new to them.

In the preparation of this bulletin the demand for this kind of information has been kept in mind, and the work has been outlined so as to give ideas and suggestions in regard to our methods and practices for growing watermelons and cantaloupes. The results of the investigations with these crops at the Station are also reported.

Mr. J. B. Thompson, former Assistant Horticulturist, kept all the notes on the yields and made most of the descriptions of the varieties reported in this bulletin.

### **WATERMELONS**

#### **Soil**

The watermelon prefers a warm, sandy, fertile loam; but not so rich a one as to produce too rank a growth of the vine and thus a poorer quality of melons. On the other hand, if the soil is too poor, there will not be enough produced to pay for the cultivation.

The soil should be loamy enough to conserve the moisture well. A soil that is too light, or too heavy, loses its surface moisture very quickly and the vines suffer unless they are frequently irrigated.

#### **Laying off the Ground**

After the land has been thoroughly plowed, well harrowed or pulverized, and leveled, ditches are laid off. The common practice is to make ditches about 3 or 4 feet wide, with the

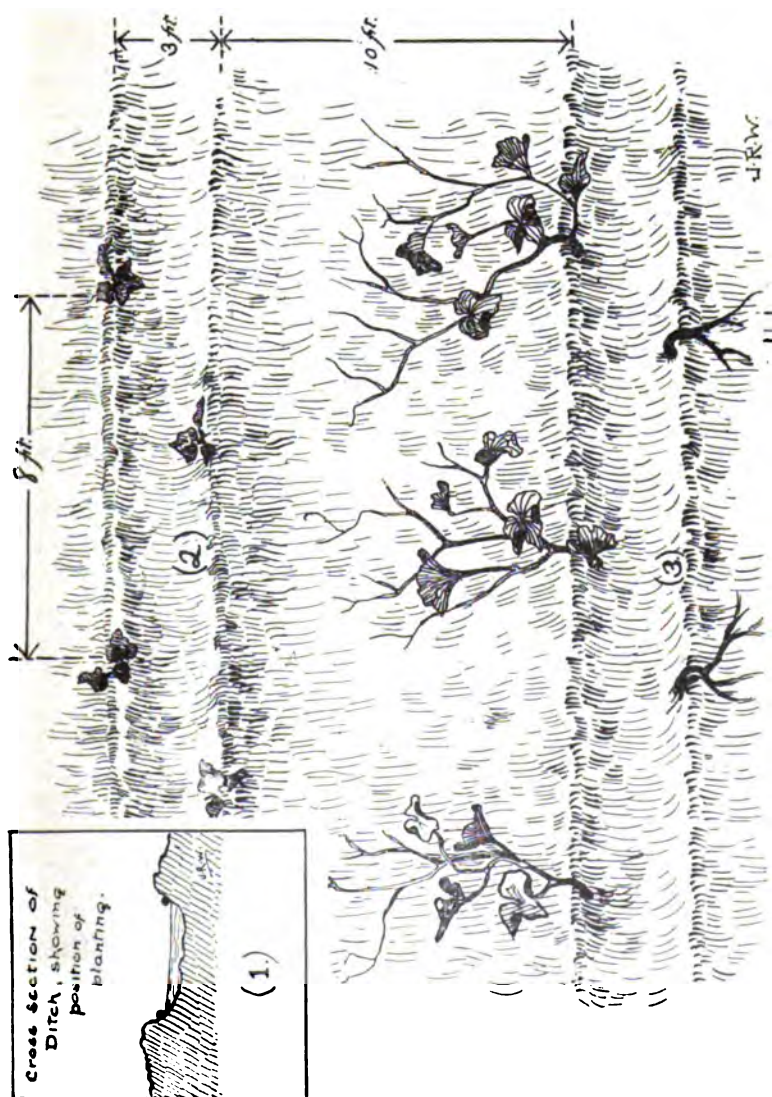


Figure 1.— (1) Cross section of ditch showing position of planting. (2) Showing ditch and position of plants on side of the border. (3) Showing ditch and vines trained back upon the middle.

borders 6 to 10 inches high. The ditches are plowed up at intervals of about 10 or 15 feet from middle to middle. This gives a space or middle from about 9 to 12 feet wide between the borders of the ditches for the vines to spread out upon. This practice is necessary to conform to our method of irrigation.

#### Distance Apart to Plant

The distance at which to plant the seed varies with the variety and with the fertility of the soil. If the soil is quite rich the distances should be greater. The common practice followed on ordinary soils is to plant the seeds from 7 to 9 feet apart in the row. The distance between the hills in the row is always less than the distance or width of middles between the ditch borders. The closer the hills are planted in the row, the wider should be the middles.

According to our system of growing watermelons more hills can be grown to the acre than by the eastern method. In the following table the number of hills per acre at different distances is given:

| Width of ditch | Width of middles | No. of hills per acre at |                |                 |
|----------------|------------------|--------------------------|----------------|-----------------|
|                |                  | 7 ft.<br>between         | 8 ft.<br>hills | 9 ft.<br>in row |
| 3 ft.          | 9 ft.            | 1037                     | 907            | 806             |
| 3 "            | 10 "             | 957                      | 837            | 744             |
| 3 "            | 11 "             | 888                      | 777            | 691             |
| 3 "            | 12 "             | 829                      | 726            | 645             |
| 4 "            | 9 "              | 957                      | 837            | 744             |
| 4 "            | 10 "             | 888                      | 777            | 691             |
| 4 "            | 11 "             | 829                      | 726            | 645             |
| 4 "            | 12 "             | 777                      | 680            | 605             |

#### Time to Plant

The watermelon is a plant that prefers a warm season for its best development. If the seed is planted very early in the season when the nights are yet quite cool, although it may

germinate, the plants do not grow fast; and the result is, as a rule, a more or less weakened and dwarfed plant. It is a noticeable fact that later plantings produce larger vines and better crops. The objection to late planting is the lateness of the ripening of the crop.

### **Planting**

It is the general rule to irrigate before planting. The water is turned into the ditches and allowed to run until they are from one half to two-thirds full. As soon as the soil is dry enough on the surface, which usually is from 3 to 4 days after irrigating, the seed is planted on the side of the ridge at the water mark. It is not a good practice to plant the seed lower down than the water mark. If it is planted too low down on the ridge, and if, as is sometimes the case, an irrigation has to be given before the seed comes up, the water will flood the hill, and the soil, in most cases, will bake and thus retard the germination and even the growth of the young plants. In planting it is always advisable to be liberal with the seed. It is best to plant more than is necessary, as in this way a better germination and a better stand may be secured. If most of the seeds that are planted germinate, they can be thinned out later. Plant from 8 to 12 or even more seeds to the hill.

### **Depth**

Where irrigation is practiced and where the humidity of the atmosphere is as low as it is in our locality, the depth at which the seeds are planted is somewhat greater than it is in the humid regions. If the seed is planted in very shallow soil, frequently it will not come up on account of the soil losing so much of its moisture before germination takes place. In such cases it is necessary to irrigate again in order that the young plants may come through the soil. The usual depth varies from 1½ to 3 inches. The depth depends on the texture and moisture condition of the soil.

### Thinning

If all, or almost all, of the seeds planted in the hills germinate, it is necessary to thin them out before they get too large. If all of the little seedlings are allowed to grow, the vines will tend to crowd each other which will result in weak plants and poor crops of inferior quality. It is advisable to thin twice. The first time, only thin to about 4 plants to the hill. This is a safeguard against mice and squirrels or insects that sometimes destroy some of the plants in the hill. At the last thinning, which should be done about the time the plants begin to send out runners, all but two plants to each hill should be removed. It is better to have one or two plants to the hill than more.

### Training the Vines

Owing to our method of irrigation it is necessary to plant the seed on the side of the ditch borders as already described, and to train the vines back over the middles. The training should be begun just as soon as the vines begin to make runners. The runners are never allowed to remain in the ditches. By training the vines back on the dry middles the melons are always on dry soil and the chances for the decay that might result from the melons resting on wet soil are considerably lessened. It is often necessary to go over the field three or more times during the earlier part of the season and turn the vines over on the higher and dry middles. This makes it necessary to handle the vines more, perhaps, than is desirable for the good of the plant. The gardener should be careful in doing the work not to injure the vines more than necessary. Some melon growers in the humid sections do not favor the practice of turning the vines. One author writes as follows:

"Never, under any circumstances, turn a vine! More will be lost by so doing than will be gained by giving the plant an extra cultivation. This is another ancestral practice and doubtless arises from the fact that vines when turned are apt to be carelessly handled. If returned gently and deftly to their

original position, it is difficult to realize how they would be injured. Any weeding that is found necessary after this time should be effected with a scythe blade, lopping off the tops of the weeds above the vines. They should not even be pulled out by hand on account of the danger of mutilating the vines which generally hold them in a tight embrace with their tendrils. Indeed, rather than risk disturbing a vine it would be preferable to leave the weeds and the melons to 'have it out' between them; for a few well-anchored weeds, here and there, prove rather a benefit than a detriment, since they prevent the winds from rolling up and matting the vines.\*"

The writer has frequently noticed that volunteer vines which happen to come up in some place in the field where they are not disturbed, grow just as well, if not better, and produce as good a crop as vines planted. Such vines get very little if any cultivation, very little water, and are never turned; while the vines planted are turned and get considerably more cultivation and irrigation. With the extra care and irrigation that the planted vines receive the results from them should be much better than from the volunteer vines; but as a rule, they are not materially better. Why there is so little difference is not known, unless the planted vines are retarded in their growth on account of so much handling and turning them back over the middles.

The practice of turning the vines back might be, partially if not altogether, done away with by making narrow ditches and planting only one row of hills in the middle of each ditch. The only handling of the vines necessary would be the turning of a few of the runners in the ditch back on the middles. This plan has not been tried at the station and is simply mentioned here as a possible modification of the old system.

#### Cultivation

The cultivation of the watermelon is very simple. It consists in hoeing the weeds in the ditches and around the vine

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\*Georgia Station Bulletin No. 38, page 75, by Hugh N. Starnes.

during its earlier growth, and in occasionally drawing up the soil to the vine with the hoe from the inside of the ditch. The middles are cultivated during the early part of the season; and as soon as the runners get large enough to take up a considerable part of the middles, cultivation is stopped. Since the middles are never irrigated, very few weeds grow in the middles. If, after cultivation has stopped, the middles get weedy, the large weeds can be pulled up by hand or they may be cut off with a scythe.

### **Irrigation**

Generally speaking, the watermelon will grow and produce a crop with a small quantity of water; but it will do considerably better if irrigation is not denied. The number and frequency of irrigations will depend to a large extent upon the soil and climatic conditions. A soil which conserves the moisture near the surface where the roots of the vines are located will require the least amount of irrigation water.

As a rule, however, under ordinary conditions the irrigation should be more frequent after the plant begins to bear. The first irrigation is usually given to the ground just as soon as the ditches are made and just before the seed is planted. If the seed is slow in germinating, it is sometimes advisable to give a second irrigation to produce germination, but care must be taken not to allow the water to cover the hills for the reason that it would pack the soil and thus retard or prevent germination. All of the irrigations are applied through the ditches. After the plants are up, when irrigating, the ditches should be well filled so that the moisture can soak into the borders and reach the roots.

### **How to Tell a Ripe Melon**

The knowledge of telling a ripe melon comes mainly by experience and observation. It is often claimed that when the little "curl" or tendril on the stem is dead, the melon is ripe; if green, the melon is also green. This is not altogether a reliable sign. The flat, dead sound emitted by the melon when thumped with the finger is also an indication of ripe-



ness. If on turning the melon over and exposing the under side, the white blotches are found yellowish, rough, and warty with the surface sufficiently hard to resist the finger nail when scratched, it is another sign of ripeness. After the melon looks ripe and thumps as if it were ripe, and if on pressing it down, the interior appears to give, and this is also accompanied by a slight crisp crackling, the melon is almost sure to be ripe. Melons that are to be shipped should not be put to this latter test.

### **Saving Seeds**

The question often comes up among melon growers as to whether they should save their own seed. This is a question that is difficult to answer definitely. On the whole it seems better to buy the seed from the seed firms. If the seed has been properly selected, as it should be, there can be no doubt but that this is the better plan for the grower to follow. However, if the grower should decide to save his own seed from his crop, he should keep in mind certain rules. In the first place the object in saving one's own seed should be to improve the variety and adapt it to the local conditions; and in doing this, one should be very careful in selecting the best. In order to select the best a number of features should be considered. One should take into consideration the vigor and prolificness of the plant, the size, and quality of the melons, as well as the resistant qualities against drought and disease. Usually the common practice is to select seed from one large watermelon, simply because it is large. This practice, based simply on size, is not considered advisable. To go a step further, after considering all the above points, one should cut open each melon and taste it for quality, texture, and color of flesh. In this way the seed of any insipid melon or any that may have any interior defects can be eliminated. While this may appear to be a rigorous procedure, it is, nevertheless, the only proper method to follow in saving seed.

### **Insects and Diseases**

So far, melons do not seem to be troubled with any serious diseases. Occasionally a few vines are found affected with a wilt disease. From external appearance of the vine, it resembles very much the wilt disease reported by E. F. Smith.† During rainy seasons there has also been noticed a fungus on the leaves of both watermelon and muskmelon vines. These diseases, however, so far, have not been serious enough to attract much attention.

#### **Striped Cucumber Beetle**

This insect is liable to do some damage especially to the young melon vines early in the spring. The insect can be recognized by its yellow and black striped wing-covers. It is about  $\frac{1}{4}$  of an inch in length and does not appear in very large numbers. It belongs to the chewing insects and in order to kill it some of the poison mixtures should be used. While we have not tried any of the mixtures on this beetle, Paris green is recommended by some of our authorities, and there is no doubt that arsenate of lead will be a good poison for it.

The Paris green is used at the rate of 4 ounces to 50 gallons of water, while arsenate of lead can be used at the rate of 3 to 6 pounds to 50 gallons of water. Tobacco dust and air-slacked lime, which tend to drive away the insects, are sometimes dusted on the young plants.

#### **Grasshopper**

The grasshopper is sometimes troublesome to the young watermelon plants. If they are numerous, it is a very difficult task to prevent them from doing a great deal of harm.

Poisoned bran can be used, and this, together with the spraying of the plants with arsenate of lead, will give more satisfactory results. The poisoned bran is prepared by mixing one to two pounds of Paris green or arsenic and 20 to 50 pounds of bran together with enough water to thorough-

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† Bulletin No. 17 U. S. D. A. Division of Vegetable Physiology and Pathology. Nov. 22, 1899.

ly moisten the mass. Add to this one or two pounds of sugar, or a little molasses, so that the bran will stick together. The poisoned bran can then be distributed in small quantities close to the vines.

### The Squash Bug

This is at present one of the worst insect pests the melon grower has to deal with. The insect attacks watermelons, muskmelons, cucumbers, and squashes, and is most destructive to the last mentioned crop. It appears in the early part of the summer; and, if allowed to go undisturbed, it will multiply rapidly and soon becomes very destructive. The insect has a dull grayish brown color, and is between one-half and three-fourths of an inch in length. It is a ready flier but a poor runner. Sometimes it is called the *stink-bug* on account of its offensive musky odor which is given off when the insect is handled. It lays its eggs in clusters on the under side of the leaves and they soon hatch into numerous little bugs.

It is a sucking insect and one of the most difficult ones to control after it gets started. Spraying with kerosene emulsion is recommended. One of the best ways to keep the insect from multiplying is to pick them off in the early part of the season when they first appear. This is a slow work, but it will pay in the long run and especially on small plantations. It is also well to cut off and burn all of the leaves containing the eggs.

These insects like to hide under shelter and especially on a cool night. By placing shingles close to the vines many insects can be trapped and then killed.

These insects prefer the squash vines and when melons and squashes are growing close together they will attack the latter first. As soon as the insects get quite numerous on the squash vines, the vines should be destroyed. If this is not done, and, if the insects get beyond control, as soon as the squash vines die, which they do in a comparatively short time, the insects will march over to the melon patch. During

the summer of 1906 the writer saw a large part of a cantaloupe field almost ruined by the squash bugs. These bugs had started on a row of squash vines adjoining the melon patch and then marched over to the melons. If the squash vines are planted as a trap for the squash bug, they had better be destroyed before the insects have become too numerous; if planted for raising squashes, they had better not be planted close to a melon field.

#### **The Melon Louse**

The melon louse is also a sucking insect; and while it is not a serious pest yet, it is very destructive whenever it affects the vines. The presence of this insect can always be told by the blackish appearance of the leaves. The leaves and vines affected by the melon louse look as though soot had been dusted on them; and they are more or less sticky from the secretion of the insects. The insect is not an easy one to check after it gets started, and the only direct remedies are kerosene and whale oil solutions and carbon bisulphide.

#### **Mice and Ground Squirrels**

Another trouble the melon growers may expect will be from mice and squirrels. Field mice and squirrels are frequently troublesome to the seed and young plants in new fields.

The best remedy that we have tried has been poisoned wheat. The wheat is scattered very liberally along the rows close to the hills.

#### **Station Test**

In 1906 a test was conducted with watermelons on the new horticultural farm. The land used for this experiment had not grown any kind of a crop for thirty or more years, and the wind had made a number of small sand hills in different places. The soil is a very light loam, and is well suited for melons and similar crops. After the land was leveled, it was plowed, disced, and harrowed. On April 2d it was heavily irrigated from the ditch, the first time it had been irrigated for years. On April 9th a half acre plat was measured off

and planted to 7 rows of Gypsy or Rattlesnake and 3 rows of the Mammoth Iron Clad watermelons. The rows were 380 feet long. Instead of plowing out ditches three or four feet wide and planting the seed on the inside of the ridges according to the common practice already explained, shallow furrows were plowed out with a six inch plow, allowing 3 feet between the rows where the ditch was to go, and 9 feet space for the middles for the vines to be trained back upon.

Eight to twelve seeds to a hill were then dropped in these shallow furrows 7 feet apart, and covered by plowing back another shallow furrow from the inside, thus leaving a ditch for the irrigation water. The seed was covered from 2 to 3 inches deep. The soil was moist enough to produce good germination, and had it not been for the field mice and squirrels there would have been a good stand. These animals proved to be quite destructive. Most of the damage was done at night. Many of the young plants were cut off just below the seed leaves.

On account of the depredations of these animals it was necessary to replant with seed of the Florida Favorite variety before a good stand was secured. Poisoned wheat was liberally used and it proved to be quite effective. The wheat was scattered on the surface along the rows where the mice and squirrels had no trouble to find it.

On July 28th the squash bug was discovered on a large number of the vines, and immediately two men were set to picking them off. The insects were picked off clean enough so that they were of no more trouble the rest of the season.

About a fifth of the plat was somewhat higher than the rest and it was difficult to hold the water on this part long enough for the soil to become thoroughly wet through. This resulted in the vines on this high place making a smaller growth and producing a smaller and an inferior crop of watermelons.

While the distance of 7 feet between the plants in the rows was barely enough, the 9 feet middles for the vines to spread out on was not enough space. The 9 feet middles crowded

the vines too much. The hills were thinned to two plants.

The treatment during the summer consisted in irrigation, cultivation, both in the ditches and the middles, and in hoeing the weeds out.

The first three irrigations after the seed was planted were given with ditch water; the rest were given with well water from the pumping plant on the horticultural farm.

The following, which is an itemized statement of the work done on this one-half acre plat during the season, will give an idea of the different operations and cost of each:

|                                                                        | Hours | Min. |
|------------------------------------------------------------------------|-------|------|
| Plowing, harrowing, and leveling the $\frac{1}{2}$ acre.....           | 5     |      |
| April 2—One man irrigating—flooding the whole surface—from ditch ..... | 1     |      |
| April 2—One man watching head gate on main ditch.....                  | 1     |      |
| April 9—Furrowing for the ten rows with a small plow .....             |       | 25   |
| April 9—Dropping seed in the furrows—7 feet apart.....                 |       | 40   |
| April 9—Covering the seed with a small plow....                        |       | 25   |
| April 9—Smoothing the furrows down .....                               |       | 25   |
| May 15—Replanting the missing hills by hand...                         | 5     |      |
| June 5—Irrigating in the ditches with ditch water                      |       | 50   |
| June 5—Watching head gate at main ditch. ....                          | 1     |      |
| June 12—Irrigating with ditch water.....                               |       | 45   |
| June 12—Watching head gate at main ditch.....                          | 1     |      |
| June 19—Irrigating with ditch water.....                               |       | 40   |
| June 19—Watching head gate at main ditch.....                          | 1     |      |
| June 22—Hoeing in ditches and middles and thinning hills.....          | 15    |      |
| July 6—Cultivating in ditches and middles.....                         | 3     |      |
| July 10—Irrigating with pump water—(engine working very poorly).....   | 1     | 30   |
| July 27—Cultivating in ditches and middles.....                        | 3     |      |
| July 27—Hoeing in ditches and middles.....                             | 16    |      |
| July 28—Picking off squash bugs.....                                   | 15    |      |

|                                               | Hours    | Min.  |
|-----------------------------------------------|----------|-------|
| Aug. 3—Irrigating with pump water.....        |          | 30    |
| Aug. 13       "       "       "       " ..... |          | 35    |
| Aug. 24       "       "       "       " ..... |          | 28    |
| Sept. 1       "       "       "       " ..... |          | 32    |
|                                               |          | <hr/> |
| Total.....                                    | 74       | 45    |
| 74½ hours at 10c. per hour ...                | \$7.475  |       |
| Naphtha used (for the 5 irrig.) 10.27 gal-    |          |       |
| lons at 13c. per gal.....                     | 1.33     |       |
| Engineer's wages (for the 5 irrig.) 3 hours   |          |       |
| 35 minutes at 12c per hour. ....              | .43      |       |
|                                               |          | <hr/> |
| Total cost .....                              | \$ 9.235 |       |
| Cost per acre.....                            | 18.43    |       |

The figures in this table simply show the actual time required for each operation. The time that it took the water to reach the field from the pump and from the ditch, and also the time in going to and from the corral to the field was not taken into consideration, nor were the team and machinery included in the cost. The cost of picking and handling the crop was not recorded.

Owing to the fact that the horticultural farm is irrigated through a high *contracequia* or lateral ditch, it is necessary at at every irrigation to have, in addition to the man taking care of the water in the field, an extra man watching the head gate at the main ditch. This adds a man's wages to the cost of irrigation. It is also noticed that it took longer to irrigate from the ditch than from the pump. This was due to the smaller quantity of ditch water used at the time.

The engineer's wages and cost of the fuel is to be added to the other costs. The watermelon plat, as is seen from the table, was irrigated five times with pump water. The time it took for the first irrigation on July 10 was practically three times as long as it did for each of the other four irrigations. This was due to the engine working very poorly. It was impossible to measure the amount of water pumped and the

naphtha used during the run; but, judging from the time it took and from the data obtained during the last irrigation, it is probably safe enough for all practical purposes to calculate the cost of this run on the basis of the cost of the last irrigation.

The total time for the last four irrigations was 125 minutes or an average of  $31\frac{1}{4}$  minutes for each irrigation. Neither the amount of water pumped nor the naphtha used was measured, except in the last irrigation. 912 gallons per minute were pumped and the engine consumed .53 pints of naphtha per minute or 3.97 gallons per hour. The naphtha used during the season cost 13c per gallon laid down at the farm.

The cost of the naphtha consumed by the engine during the season is calculated from the figures obtained during the last irrigation. The engineer was one of our farm hands who had learned to run the engine and was paid at the rate of only 12c per hour. Had a regular engineer been hired, the cost would have been greater.

#### Pickings from $\frac{1}{2}$ Acre Plat Season of 1906

| Date    | No. Picked | Pounds | Date        | No. Picked | Pounds |
|---------|------------|--------|-------------|------------|--------|
| Aug. 20 | 5          | 125    | Sept. 6     | 9          | 189    |
| " 28    | 37         | 554    | " 8         | 33         | 404    |
| " 30    | 4          | 80     | " 15        | 42         | 573    |
| Sept. 1 | 44         | 725    | " 27        | 39         | 629    |
| "       | 2          | 80     | " 28        | 14         | 252*   |
| " 3     | 20         | 500    | Oct. 2      | 36         | 564*   |
| " 4     | 30         | 517    | " 5         | 56         | 672*   |
| " 5     | 25         | 500    | " 7         | 766        | 8426*  |
| " 5     | 22         | 330    |             |            |        |
|         |            |        | Total Yield | 1183       | 15120  |

\*Estimated weight.

While there were no very large specimens, there were a great many of good shipping size. Only melons weighing ten pounds and over were included in the test. A few specimens weighed as high as forty pounds. Those that were



sold to the local dealers and peddlers weighed from twelve to eighteen pounds. This seemed to be a very popular size. On October 5th and 6th the vines were killed by frost and all of the melons weighing over ten pounds were picked. The yield would have been somewhat greater if there had not been a poor spot in the middle of the plat.

### VARIETIES

Some of the leading varieties such as the Kentucky Wonder, Sweetheart, Seminole, and Kolb's Gem reported from some of the leading melon growing states did not give very satisfactory results. Among the more satisfactory varieties tested were the Phinney's Early, Cuban Queen, Mammoth Iron Clad, Gypsy or Rattlesnake, and Florida Favorite. The three last named varieties were the favorite ones.

### Variety Test

On June 21st, 1906, six hills each of 13 varieties of water-melons were planted. The following are the descriptions of the varieties grown:

**Black Diamond**—Size, medium to large; shape, round to oblong; color, deep green; rind, tough and medium thick; flesh, fairly solid, pink or pale red, coarse, and of only fair quality; seeds, medium, black.

**Black Spanish**—Size, small; shape, roundish to slightly oblong; color, deep green, almost black; rind, thin and hard; flesh, light red, sweet, juicy, fair quality; seeds, black. Season, medium early.

**Cuban Queen**—Size, very large; shape, round, with a tendency in some specimens to oblong; color, light green with darker green stripes; rind, medium to thick; flesh, red, crisp, sweet and good; seeds, black; vine not prolific but melons grow uniformly large. Season, medium late.

**Dixie**—Size, medium to large; shape, long; color, dark green with more or less broken stripes of lighter green; rind, medium to thick; flesh, pink, sweet, juicy; seeds, black. Season, medium early.

**Florida Favorite**—Size, medium to large; shape, long; color, dark green mottled and striped with darker green stripes; rind, medium thick; flesh, rich red, crisp, sweet, excellent quality; seeds, white; vine, fairly prolific. A good general purpose melon. Early to medium season.

**Gypsy or Rattlesnake**—Size, large; shape, oblong; color, light green, with darker green stripes; flesh, red, crisp, good; seeds, light buff with dark buff or black eyes. Vine, fairly prolific. A good shipping melon. Medium season. Resembles the Mammoth Iron Clad.

**Jones Jumbo**—Size, large; shape, roundish to slightly oblong; color, dark green marked with faint lighter green stripes; rind, thick; flesh, sweet, good quality; seeds, white. Vine not prolific but melons quite uniform in size.

**Kentucky Wonder**—Size, small to medium; shape, oblong; color, dark green, marked with light green tracery; rind, thin; flesh, solid, light pink to scarlet; flavor, fair; seeds, buff to brown. Season, medium early. Not extra good shipper owing to the thin rind.

**King and Queen**—Size, small to medium; shape, round globular; color, creamy white with very faint markings of yellowish green stripes; rind, very hard and thin; flesh, solid, deep red, fairly sweet, juicy; seeds, small numerous, black or white clouded with black, varying. Season, medium early.

**Kolb's Gem**—Size, medium to large; shape, round to oblong; color, striped with more or less irregular stripes of dark green and white, the white stripes mottled with green; rind, medium thin but hard and tough; flesh, bright red, coarse, sweet, juicy; seeds, large, numerous, black.

**Mammoth Iron Clad**—Size, large; shape, oblong, many specimens tend to be pointed; color, light green with dark green stripes; rind, thin but firm; flesh, red, good, firm; seeds, light buff. Medium season. Quite satisfactory.

**McIver's Wonderful**—Size, large; shape, long; color, light

green with web work of darker green and bearing longitudinal stripes of a still darker green; rind, medium thick; flesh, solid, sweet, juicy, light red, good quality; seeds, white.

**Phinney's Early**—Size, medium; shape, oblong with a slight tendency to taper toward calyx end; color, deep green with light green longitudinal markings; rind, thin; flesh, light red, not very solid; flavor, good; seeds, white with black points. Prolific and early.

**Mountain Sweet**—Size, medium; shape, slightly oblong; color, deep green, uniform rough surface; rind, medium thick; flesh, fairly firm and crisp, light red in color, sweet, juicy and of good quality; seeds, black, mottled with brown.

**Seminole**—Size, medium to large; shape, oblong; color, very light green with darker green tracery; rind, extremely thin, solid; flesh, bright red, crisp, good quality; seeds, medium, brown. Season, early. A poor shipper.

**Sweetheart**—Size, small to medium; shape, round to oval; color, light green, nearly white, marked with darker green lacing; rind, thin, solid; flesh, deep red, solid, permeated by numerous white fibrous cords; seeds, large, black but not numerous. Season, early.



Figure 2.—(1) Gypsy or Rattlesnake  
(2) Mammoth Iron Clad  
(3) Florida Favorite—Three good varieties.

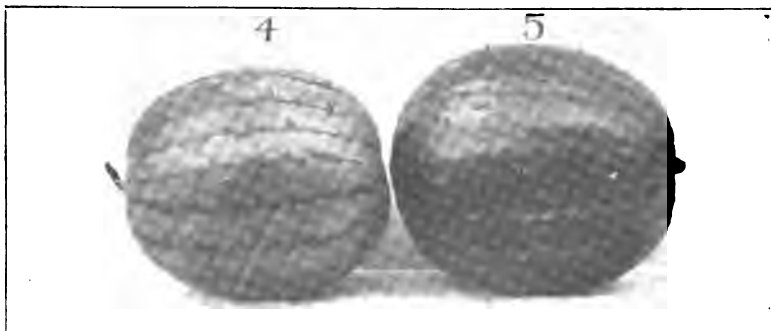


Figure 3.—(4) Cuban Queen (5) Jones Jumbo.

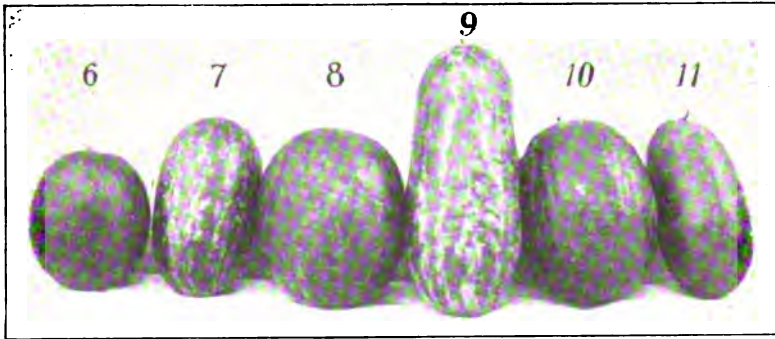


Figure 4.—(6) Black Spanish (7) Phinney's Early (8) Black Diamond (9) Dixie (10) Mountain Sweet (11) Kentucky Wonder.



Figure 5.—(12) King and Queen (13) Kolb's Gem (14) Seminole (15) McIver's Wonderful (16) Sweetheart.

## MUSKMELONS

The muskmelon, like the watermelon, is an annual trailing plant very sensitive to frost, bearing fruits weighing from 1 to 10 pounds. It is successfully grown in all the horticultural districts in the territory and especially in the lower and warmer valleys. It resembles the watermelon in manner of growth and in most of its cultural requirements. Therefore, the discussions under *soil, laying off the ground, distance apart to plant, time to plant, planting, depth, thinning, training or turning the vines, cultivation, irrigation, saving seed, insects and diseases* for the watermelon, with very few modifications, can be applied to the muskmelon.



Figure 6—Muskmelon field showing method of planting in ditches and training the vines back upon the middles.

The distance between the ditches, or width of middles, and the distance between the plants in the row are less than for watermelons. The width of the middles may vary from 6 to 8 feet and the distance of the hills in the rows from 5 to 7 feet.

From 10 to 15 seeds, at least, should be planted to the hill. While the muskmelon seed may come through 3 inches or even more of soil, it is better to plant it from 1 to 2½ inches

deep. The following table gives the number of hills per acre at different distances:

| Width of Ditches | Width of Middles | No. of hills per acre at |                |                 |
|------------------|------------------|--------------------------|----------------|-----------------|
|                  |                  | 5 ft.<br>between         | 6 ft.<br>hills | 7 ft.<br>in row |
| 3 ft             | 6 ft             | 1936                     | 1613           | 1382            |
| 3 "              | 7 "              | 1742                     | 1452           | 1244            |
| 3 "              | 8 "              | 1584                     | 1320           | 1131            |
| 4 "              | 6 "              | 1742                     | 1452           | 1244            |
| 4 "              | 7 "              | 1584                     | 1320           | 1131            |
| 4 "              | 8 "              | 1452                     | 1210           | 1037            |

### Picking Ripe Muskmelons

There seems to be no set rule for picking ripe muskmelons that will apply to all varieties. The muskmelon should not be allowed to fully ripen or turn yellow upon the vine. When this is done, the fine flavor and texture of the flesh deteriorates. Practically all of the smaller or Gem type *crack about the stem as soon as the melon begins to ripen*. When this takes place, and if the melon pulls off easily, leaving the stem attached to the vine, the fruit is ready for market. Often the cracking about the stem is accompanied by the secretion of a few drops of a yellowish colored juice.

The stem of some of the large growing varieties does not usually separate from the fruit, and if it does, quite a large hole is left in the melon. A better way to tell when to pick these large melons is, perhaps, to watch the yellowing of the fruit which usually appears in the middle of the melon. When these yellow tracings appear, the melons are ready to be picked. After the melon begins to ripen, cool and cloudy weather tends to retard the ripening, while bright sunny days ripen the fruit very quickly.

### Forcing Cantaloupes

Earlier melons may be had from plants forced under glass. There are two ways of starting the plants. One is by planting two or three seeds in two or three inch pots early in the season. The neponset paper flower pots are very satisfactory. The pots are placed as close together as possible in cold frames which are covered with glazed sash, and the treatment of the plants in the pots is the same as for any other plant growing in a cold frame. It is advisable to cover the sash with some kind of a matting or some heavy cloth during the cooler nights. The watering and the ventilating require constant attention. If all the seeds germinate, the little plants will soon begin to crowd each other and this may induce a spindling growth. As soon as the plants have produced true leaves and are beginning to crowd each other, they should be thinned. It is very desirable to produce as stocky plants as possible, because they will stand transplanting better than spindling ones. See Fig. 7. The plants are transplanted to the field as early as possible after all danger of frost is over. Before transplanting, the plants should be allowed to harden. This can be done by gradually reducing the temperature in the cold frames till the plants may be left uncovered at nights. By gradually hardening the plants in the cold frames they will adapt themselves to the new field conditions much better.



Figure 7.—A plant started in a neponset paper pot, right size for transplanting.



The other method, and the more common one in this section, is by means of small glass-covered boxes. These boxes may be made from inch lumber, 8x10x12 inch with a groove for a 10x12 inch glass or any other size desired. The cantaloupe seed is planted in the field as early as possible in the spring and the glass-covered boxes are placed over the hills; at the station the seed has been planted as early as March 25th.

The seed soon germinates and the plants grow right along without being injured by the low night temperature. If it can be so arranged, it is desirable to have the boxes sloping slightly to the south and east. After the plants have come up care should be taken in ventilating. The general practice of some growers is to remove the box in the forenoon, and in the afternoon to place it back again. Others simply pull the glass out a few inches. The latter method seems to be better for the reason that the plant gets plenty of air and at the same time is protected from the cool and hard winds that are likely to blow during the day. The boxes are removed after all danger of frost is over. The plants should be hardened before the boxes are removed.

#### **Station Test**

In the spring of 1904 an experiment was started in forcing Rocky Ford cantaloupes in the field by means of small (8x10x12 inch) field cold frames. The approximate cost of each of these boxes, including the 10x12 inch, double strength A pane of glass was 19 cents. On March 25th, forty hills were planted. The seed could have been planted as early as March 5th at the time when a number of tomato hills were planted. By April 12th the seeds in the boxes were coming up. On May 18th when the vines were beginning to form runners, all the boxes were removed from the plants. The first ripe cantaloupes were picked on July 10th. Had the seed been planted earlier in the spring, there is no doubt that the melons would have started to ripen earlier. The melons from 20 vines were picked, counted, and weighed as fast as they ripened during the season.

## MELON CULTURE

The following table gives the dates of picking, number of vines picked, number and weight of melons:

| Date    | No. of Plants | No. melons picked | Actual wt. in lbs. | Date    | No. of Plants | No melons picked | Actual wt. in lbs. |
|---------|---------------|-------------------|--------------------|---------|---------------|------------------|--------------------|
| July 10 | 3             | 4                 | .....              | Aug. 8  | 3             | 4                | 6                  |
| " 12    | 1             | 2                 | 1½                 | " 9     | 9             | 12               | 13½                |
| " 14    | 4             | 4                 | 4½                 | " 10    | 5             | 5                | 7                  |
| " 15    | 1             | 1                 | 1½                 | " 11    | 5             | 8                | 10½                |
| " 16    | 1             | 2                 | 1½                 | " 12    | 8             | 12               | 18½                |
| " 17    | 2             | 2                 | 2                  | " 13    | 6             | 5                | 8                  |
| " 18    | 4             | 5                 | 5½                 | " 15    | 9             | 10               | 13                 |
| " 19    | 3             | 3                 | 3½                 | " 16    | 10            | 12               | 19                 |
| " 20    | 3             | 8                 | 3                  | " 17    | 6             | 6                | 10                 |
| " 21    | 1             | 1                 | 1                  | " 18    | 8             | 8                | 10½                |
| " 22    | 2             | 2                 | 8 1-16             | " 20    | 4             | 7                | 9                  |
| " 23    | 1             | 1                 | 1                  | " 22    | 13            | 14               | 21                 |
| " 24    | 4             | 7                 | 6                  | " 23    | 6             | 6                | 10                 |
| " 25    | 2             | 2                 | 2½                 | " 24    | 6             | 6                | 10½                |
| " 26    | 2             | 3                 | 7                  | " 25    | 4             | 4                | 5½                 |
| " 27    | 9             | 13                | 18                 | " 26    | 10            | 13               | 17                 |
| " 28    | 4             | 5                 | 6                  | " 27    | 4             | 7                | 12                 |
| " 29    | 5             | 9                 | 13½                | " 28    | 4             | 6                | 9½                 |
| " 30    | 12            | 16                | 25½                | " 30    | 6             | 6                | 9                  |
| Aug. 1  | 12            | 16                | 23                 | " 31    | 6             | 6                | 7½                 |
| " 2     | 9             | 14                | 20                 | Sept. 1 | 6             | 10               | 13½                |
| " 3     | 14            | 19                | 27½                | " 2     | 6             | 11               | 13                 |
| " 4     | 3             | 3                 | 4                  | " 3     | 5             | 5                | 7                  |
| " 5     | 10            | 13                | 22                 | " 5     | 7             | 7                | 11                 |
| " 6     | 11            | 11                | 19                 | " 6     | 6             | 6                | 9                  |
| " 7     | 5             | 9                 | 12½                | " 10    | 1             | 1                | 1½                 |

Total..... 367      315 5-16

Average weight..... 1.4 lbs.

From this table it is noticed that the Rocky Ford cantaloupe does not grow very large. The size was quite uniform throughout the season. With the exception of the cantaloupes picked on July 12, 16, and 24, which averaged less than a pound each, and those picked on July 26th averaging  $2\frac{1}{2}$  pounds, the average weight of those picked at each different picking varied from 1 to 1 8-11 pounds. The average weight for the season was 1 2-5 pounds. The average yield per plant was about 18 cantaloupes.



Figure 8.—Good Rocky Ford specimens.

In 1906 an experiment was conducted with a  $\frac{1}{2}$  acre plat of Rocky Ford cantaloupes on the new horticultural farm. The plat used for this test was one adjoining the watermelon area already described. The soil was a very light loam. The method of preparing the land and planting the seed was the same as for the watermelons, except that the middles were  $6\frac{1}{2}$  feet wide and the hills in the row  $5\frac{1}{2}$  feet apart. The half acre plat was planted on April 9th and from 10 to 15 seeds were dropped into a hill. There was a poor stand from this

planting on account of the field mice and squirrels eating the seed and some of the small plants.

On May 15th a man replanted the plat, making a small hole with a garden trowel for the seeds, which were covered not over two inches in depth and packed down with the foot. On June 1st a few more missing hills were again replanted. Poisoned wheat was again used for the mice and squirrels with good results. After the vines had made their growth in the summer they were somewhat crowded in the middles. Middles of seven or eight feet wide would have been much better than the  $6\frac{1}{2}$  feet space.

The squash bug, which started on the watermelons but which was picked off on July 28th, did not bother the cantaloupe vines. A few vines were affected by the melon aphid late in the fall, but not seriously. There was about 1.5 of the plat that produced small vines and smaller and fewer cantaloupes. This was on account of its being somewhat higher than the rest, and of its being difficult to hold the water on it long enough for the soil to become thoroughly wet.

The treatment in regard to cultivation, hoeing, and irrigation was practically the same as for the watermelons. The following statement will give an idea of the different operations and the cost of each performed on the  $\frac{1}{2}$  acre plat:

|                                                                      | Hours | Min |
|----------------------------------------------------------------------|-------|-----|
| Plowing, harrowing, and leveling.....                                | 5     |     |
| April 2—Irrigating-flooding the whole surface<br>from the ditch..... | 1     |     |
| April 2—Watching head gate on main ditch.....                        | 1     |     |
| April 9—Furrowing for the 12 rows with a small<br>plow.....          |       | 30  |
| April 9—Dropping the seed in the furrow $5\frac{1}{2}$ feet          |       | 50  |
| April 9—Covering the seed with a small plow....                      |       | 30  |
| April 9—Smoothing the furrows down.....                              |       | 20  |
| May 15—Replanting the missing hills by hand...                       | 5     |     |
| June 1—Replanting the missing hills by hand...                       | 3     |     |
| June 5—Irrigating with ditch water.....                              |       | 55  |

|                                                                      | Hours    | Min |
|----------------------------------------------------------------------|----------|-----|
| June 5—Watching head gate at main ditch.....                         | 1        |     |
| June 12—Irrigating with ditch water.....                             |          | 45  |
| June 12—Watching head gate at main ditch.....                        | 1        |     |
| June 19—Irrigating with ditch water.....                             |          | 45  |
| June 19—Watching head gate at main ditch.....                        | 1        |     |
| June 28—Hoeing in ditches and thinning plants..                      | 19       |     |
| July 7—Cultivating in ditches and middles.....                       | 3        | 30  |
| July 10—Irrigating with well water (engine work-<br>ing poorly)..... | 1        | 30  |
| July 25—Cultivating ditches and middles....                          | 3        |     |
| July 26—Hoeing of ditches and middles.....                           | 8        |     |
| July 26—Turning vines back and forth in order<br>to cultivate.....   | 5        |     |
| Aug. 3—Irrigating with well water.....                               |          | 35  |
| Aug. 13—“ “ “ “ .....                                                |          | 35  |
| Aug. 24—“ “ “ “ .....                                                |          | 30  |
| Sept. 1—“ “ “ “ .....                                                |          | 30  |
| Total.....                                                           | 65       | 15  |
| 65½ hours at 10c.....                                                | \$6.525  |     |
| Engineer's time (5 irrigations) 3½ hours at<br>12c.....              | .44      |     |
| Naphtha used (5 irrigations) 10.6 gallons<br>at 13c.....             | 1.38     |     |
| Total cost....                                                       | \$ 8.345 |     |
| Cost per acre.....                                                   | \$16.690 |     |

In the above figures, which show the actual time and cost of each operation, the cost of picking and handling the crop was not recorded. The cost of growing the one half acre of muskmelons was less than the cost for growing the one half acre of watermelons. The field was irrigated four times from the ditch and five times from the pump, the same as the watermelons. With a single exception, it took longer to irrigate with ditch water than it did with well water. This was on account of the smaller quantity of ditch water used. On account of the engine working very poorly on July 10th, it

took about three times as long to irrigate the plat as it did for each of the last four irrigations. The total time for the last four irrigations was 130 minutes, or an average of  $32\frac{1}{4}$  minutes for each irrigation.

The engineer's actual time of running the engine for the five irrigations was 3 hours and 40 minutes, at 12 cents per hour, or a total cost of 44 cents.

The actual amount of naphtha consumed by the engine for the five runs, was 10.6 gallons, costing 13 cents per gallon, or a total cost of \$1.37. Since on July 10th the engine was only doing about 1-3 the work it did during each of the last four runs, the amount of naphtha consumed was probably not over a third the amount consumed when the engine was pumping at the rate of 912 gallons per minute.

The following is a record of the Rocky Ford cantaloupes picked from the half acre during the season of 1906:

| Date    | Market size doz. | Unsound doz.  | Small size doz. | Date     | Market size doz. | Unsound doz.   | Small size doz. |
|---------|------------------|---------------|-----------------|----------|------------------|----------------|-----------------|
| Aug. 10 | $\frac{1}{2}$    |               |                 | Sept. 10 | 10               | 1              | 1               |
| " 15    | 1                |               |                 | " 12     | 13               | 1              | 1               |
| " 17    | $1\frac{1}{2}$   |               |                 | " 14     | 10               | 2              | 3               |
| " 20    | 3                | 1             | $\frac{1}{2}$   | " 17     | 12               | 1              | 2               |
| " 22    | 6                | $\frac{1}{2}$ | $\frac{1}{2}$   | " 18     | 15               | 1              | $1\frac{1}{2}$  |
| " 23    | $4\frac{1}{2}$   | $\frac{1}{4}$ | $\frac{1}{2}$   | " 20     | 16               | 1              | 3               |
| " 25    | 12               | $\frac{1}{2}$ |                 | " 22     | 12               | $1\frac{1}{2}$ | 3               |
| " 28    | 12               |               |                 | " 25     | 39               | $2\frac{1}{2}$ | 8               |
| " 29    | 2                | $\frac{1}{4}$ |                 | " 26     | 6                |                |                 |
| " 30    | $17\frac{1}{2}$  | $\frac{1}{2}$ | 1               | " 28     | 15               | 1              | $3\frac{1}{2}$  |
| " 31    | 8                | $\frac{1}{2}$ | 1               | " 29     | 12               |                | 2               |
| Sept. 1 | $2\frac{1}{2}$   | $\frac{1}{2}$ | $\frac{1}{2}$   | Oct. 2   | 5                |                |                 |
| " 3     | 8                | $\frac{1}{2}$ | $\frac{1}{2}$   | " 3      | 3                |                |                 |
| " 4     | 7                | 1             | 1               | " 4      | 3                |                |                 |
| " 5     | 5                | 1             | 1               | " 5      | 5                |                |                 |
| " 6     | $12\frac{1}{2}$  | $\frac{1}{2}$ | $\frac{1}{2}$   |          |                  |                |                 |
| " 7     | 8                | $\frac{1}{2}$ | 1               |          |                  |                |                 |
| " 8     | 13               | $\frac{3}{4}$ | 1               |          |                  |                |                 |
|         | 119              | 8             | 9               |          | 176              | 12             | 28              |

The table shows that 295 dozen of marketable size cantaloupes were picked. The first 30 dozen picked were sold to the local dealers at 30 cents per dozen. A few dozen were sold at a price from 20 to 15 cents. The rest were picked, counted, and thrown away. The profits will depend upon the earliness of the crop and upon the market.



Figure 9—A Crate of Rocky Ford Cantaloupes.

#### **Variety Test**

On June 21, 1906, six hills each of 8 varieties of muskmelons were planted. None of these varieties, according to the results obtained, proved to be any better than the common Rocky Ford cantaloupe. All of the varieties ripened a good crop of melons, a fact which goes to show that muskmelons can be planted in this climate even as late as the 21st of June.

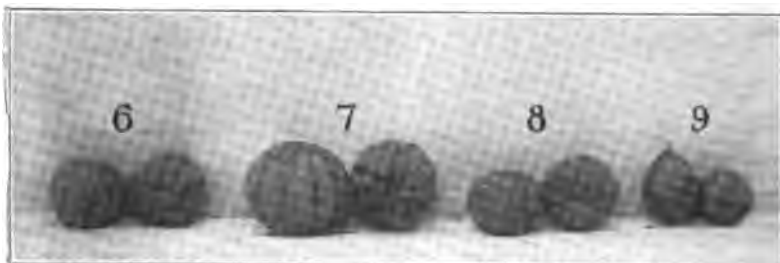
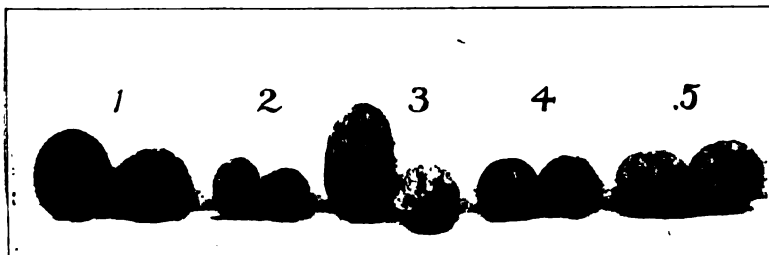


Figure 10—(1) Osage (2) Netted Gem (3) Cassaba (4) Emerald Gem  
(5) Extra Early Hackensack (6) Common Hackensack  
(7) Montreal (8) Netted Nutmeg (9) Paul Rose.

The Emerald Gem which was the earliest, started to ripen by September 12th. The following are the descriptions of the varieties grown:

**Cassaba**—Size, large; shape, long cucumber-shaped; skin, regular, heavily netted; ribs, large; deep yellowish green furrows; blossom scar, small and inconspicuous; color, deep yellow; flesh, medium thick, greenish, yellow when full ripe, coarse, juicy and of fair flavor; seed cavity, large and open. It is only a moderate yielder. First ripe melons picked September 15th.

**Emerald Gem**—Size, small to medium; shape, round, slightly pointed toward the stem; furrows, shallow forming greenish gray meridian like bands; blossom scar, large; color, emerald green interspersed with a rich orange; skin, without netting



and roughened only by the presence of minute bristly spines; flesh, very thick, dark, salmon, highly flavored, sweet and juicy; seed cavity, small and well filled with small plump seeds. When fully ripe this melon becomes soft and is a poor shipper. It has also shown, under the conditions of this experiment, a tendency to break or split open at the blossom end at the time of ripening. Moderately productive. First ripe melons picked September 12th.

**Extra Early Hackensack**—Size, large; shape, flat or oblate to round; ribs, medium and heavily netted; furrows, medium deep; color, light yellow; flesh, rather thin, greenish white, medium, firm; flavor, fair to good, juicy; seed cavity, large and open. Fairly productive. First ripe melons picked September 17th. The Hackensack seemed to be practically the same as the above.

**Montreal**—Size, large; shape, round to slightly flat; ribs, wide and very heavily netted; furrows, deep and smooth; blossom scar, medium; pale yellow color; flesh, thin, green, fair to good flavor, juicy; seed cavity, large and open. Is neither productive nor a good shipper. First ripe melons picked September 22nd.

**Netted Gem**—Size, small; shape, oblong, oval; heavily netted; furrows, very shallow and small; blossom scar, small; color, greenish brown; flesh, medium thick, green, firm, good flavor, juicy; seed cavity, medium in size. This melon is prolific and seemingly a good shipper. First ripe melons picked September 19th.

**Netted Nutmeg**—Size, medium; shape, round; ribs, wide and coarsely netted; furrows, shallow and more or less spined and light yellow when fully ripe; blossom scar, small to medium; color, yellow, a little darker than Hackensack; flesh, medium thick, green to nearly white when well ripened, juicy and of good flavor. Vine very productive. First ripe melons picked September 19th.

**Osage**—Size, large; shape, oval; ribs, wide, emerald green

underlaid with orange, lightly netted; furrows, medium deep, narrow and greenish gray; flesh, thick, deep orange, highly flavored, sweet, juicy. This melon is fairly firm and seems to be a fine shipper and produces well. First ripe melons picked September 21st.

**Paul Rose**—Size, small; shape, oval, slightly pointed toward stem; ribs, rather wide and heavily netted; furrows, shallow, smooth, and green; blossom scar, small; color, emerald green interspersed with orange; flesh, thick, firm, salmon color, good flavor, sweet and juicy; seed cavity, small and well filled. Very productive. First ripe melons picked September 22nd.

**Rocky Ford Cantaloupe**—Size, small to medium, averaging slightly over a pound in weight; shape, oval with an apparent tendency to flatten at the stem end (see figure 8); ribs, wide and heavily netted; furrows, narrow and more or less smooth and shallow; color, light yellowish; flesh, thick, firm, light green, and good flavor; seed cavity, small (see frontispiece). Prolific, producing most of its fruits close to the hill. The most popular and best all around variety for market. First ripe melons picked Aug. 10th. Had they been planted earlier, they would have started to ripen earlier.

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#### Acknowledgements

Georgia bulletin No. 38 on watermelons by H. N. Starnes; New Hampshire bulletins Nos. 52 and 70 on muskmelons by F. Wm. Rane; and bulletin No. 17 U. S. D. A. Division of Vegetable Physiology and Pathology by E. F. Smith, have been used as references.

### Summary

I.—Watermelons and muskmelons can be successfully grown in New Mexico.

II.—A fertile loam that conserves moisture well is preferable to a very sandy or extra heavy soil.

III.—The present method of growing melons is to plant the seed on the inside of ditch borders at the edge of the water mark and train the vines back upon the middles between the ditch borders.

IV.—Irrigation is done through the ditches; the middles are not irrigated. Nine irrigations were enough to produce a good crop at the station in 1906.

V.—The distance at which to plant the seed varies from 7 to 9 feet apart in the row with 9 to 12 feet middles between the ditch borders, and from 5 to 7 feet apart in the row with 7 to 9 feet middles, for watermelons and muskmelons respectively.

VI.—Melon vines are very tender, and therefore the seed should not be planted in the field until danger of killing frost is over.

VII.—From  $1\frac{1}{2}$  to 3 inches for watermelons and from 1 to  $2\frac{1}{2}$  inches for muskmelons is a good depth at which to plant the seed.

VIII.—Thin the hills to two plants before they begin to crowd each other, and train the vines back upon the middles as soon as they begin to make runners.

IX.—Most of the cultivation, which consists of hoeing the weeds out and in cultivating the ditches and middles, is done before the vines have covered the middles.

X.—Hand picking the adult squash bugs on the watermelon vines when the adult insects appeared in the early part of the season, and destroying the leaves containing the eggs, proved satisfactory.

XI.—Poisoned wheat scattered along the newly planted rows also proved quite effective for field mice and ground squirrels.

XII.—A good germination was obtained when the seed was planted in shallow furrows and covered by plowing back another shallow furrow.

XIII.—The cost of production, not including the cost of the seed and the cost of picking, was \$18.40 an acre for watermelons and \$16.69 for muskmelons.

XIV.—The Phinney's Early, Cuban Queen, Mammoth Iron Clad, Gypsy or Rattlesnake, and Florida Favorite were among the most satisfactory varieties of watermelons in the test.

XV.—The Rocky Ford cantaloupe is the most satisfactory general purpose variety. The Netted Gem, Osage, Netted Nutmeg, and Hackensack also proved to be quite satisfactory melons.

XVI.—Cantaloupes can be forced considerably by growing the plants in paper pots in cold frames and transplanting them to the field, or by starting the seed out in the field early in the season in small glass covered boxes.

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## BULLETIN No. 64

APRIL 1907

New Mexico College of Agriculture and Mechanic Arts

AGRICULTURAL EXPERIMENT STATION

AGRICULTURAL COLLEGE, N. M.



A Tuna Vendor. She Holds in Her Hand Tunas Which Sell for One Cent. The Tip of the Maguey (Agave) Leaf With Which They Are Eaten is Shown.

## THE TUNA AS A FOOD FOR MAN

BY

R. F. HARE, Chemist New Mexico College of Agriculture and Mechanic Arts  
and

DAVID GRIFFITHS, Asst. Agrostologist, U. S. Dept. of Agriculture

ALBUQUERQUE MORNING JOURNAL  
ALBUQUERQUE, N. M.

# NEW MEXICO AGRICULTURAL EXPERIMENT STATION

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# **The Tuna as a Food for Man**

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## Preface

The bulletin presented herewith represents three lines of investigation—a study of the uses of the tuna (too nah), a study of the chemical composition of the tuna, and a study of the tuna products as manufactured by the primitive peoples of the Republic of Mexico. The authors have joined these three lines of work in one report, which is here presented under the caption “The Tuna as Food for Man.” The bulletin has involved a large amount of labor in its preparation, and is a good example of the benefits to be derived by co-operation between field and laboratory workers whose special lines of investigation are diverse. The field knowledge combined with laboratory investigations always has a tendency to give economic bearing to the treatment. In this case a knowledge of the economic practises in Mexico has furnished the point of view from which the more scientific laboratory investigations have been broached.

There is presented in the paper actual economic practises, which are of interest not only to portions of the United States but to some of our insular possessions as well, botanical data necessary to the recognition of different species and varieties, and a large amount of chemical information of unusual interest. The botanical notes have been abridged as much as possible consistent with a clear presentation. In many cases they have been omitted almost entirely, but in all such cases they will be found more fully presented in Bulletin No. 60 of the New Mexico Station.

Interest in cacti in general, from both a food and a forage standpoint, has been greatly stimulated by popular writers during the past two or three years, and investigations of the nature presented herein have been sorely needed. There are but few edible tunas grown in this country, however, and these are mostly found in small, usually varietal collections of the warmer regions. In order to get an adequate idea of the

importance of the subject, and in order to secure a basis for future investigations in the development of forms better adapted to our use, it has been necessary to treat the subject from the broad point of view of the continent rather than the United States. As will be seen, a few valuable tunas are now grown within our borders. The forms, however, are comparatively few in number while the Mexican species are very numerous. Many of the latter have very desirable characteristics which if combined with species now grown here would make a very superior fruit. The data presented in this bulletin, while intended mainly as an account of the tuna as it exists today in the United States and Mexico, forms an important foundation for future investigations in the development of more desirable forms, a work which is now in progress.

The title of the writing contains the word tuna which is the Spanish for the fruit of the prickly pear plant or that section of the botanical genus *Opuntia* which bears flat jointed stems. The fruit of one *Opuntia* with cylindrical joints is also included in the bulletin for reasons stated in the text. There are many other cactus fruits that should be investigated as the tunas are here. Some work has already been done upon them and will be continued as time permits. The term pitalla (pee-tah-ya) is used by the Mexicans for a very large and heterogeneous group of cactus fruits belonging to such botanical genera as *Cercus*, *Echinocercus*, *Echinocactus*, *Pilocercus*, etc. In another publication it is proposed to treat these pitallas as the tunas are treated here.

W. J. SPILLMAN,  
Agriculturist.

U. S. Department of Agriculture.  
Washington, D. C., May 22, 1907.

## Introduction

The prickly pear of the American and Australian, the Indian fig of the Englishman, the Barbary fig of the Frenchman, the tuna of the Spanish American, and the higos chumbos of the Spaniard is a fruit concerning which there are more varied beliefs, contradictory opinions, and grades of appreciation than concerning any known to us. The plant and its fruits are subjected to both praise and abuse. While the Mexican prays that there may be no rain when the plants are in bloom that the fruit may set well and produce a good crop of tunas, the legislative assemblies in some of the Australian colonies pass laws looking toward their eradication. While the Australian governments spend much money to eradicate the "weed", some ranchmen find that it can be fed to stock with profit. While the Southern Texan was imploring the Government in the early nineties to conduct investigations looking to the eradication of prickly pear, shrewd cattlemen and ingenious machinists were devising means whereby it could be divested of its objectionable characteristics at small expense and turned to a profitable use. While the Minister of Agriculture of India pronounced against its use in unqualified terms, it was found in this country that it could play a profitable role in both beef and dairy production in at least one section of the United States. While the South African is said to revile its presence, the poorest inhabitants of the Island of Sicily are said to largely subsist on its fruit for three or four months each year. The average American traveling in Mexico can see no value whatever in the tremendous stretches of prickly pear upon the Plateau, but the native peon grows these plants and similar ones in his orchards and gives them fully as careful attention as any plants which he attempts to cultivate.

Enthusiastic magazine writers would revolutionize conditions in the arid regions by the establishment of plantations of prickly pear without spines, thus converting the most arid deserts into populous, prosperous communities. Experience teaches, however, that the spineless varieties of cultivation are not hardy under natural desert conditions; that all of the valuable spineless species which produce either fruit or forage

in economic quantities require considerable precipitation at some time during the year; and that economic species are not known which thrive under a maximum temperature of less than 10°F. One exception to this may be noted in the case of *Opuntia arborescens* of Colorado; but the amount of stock feed produced by this species is comparatively small and its distribution limited.

Conservative judgment based upon observation and experiment, on the other hand, would pronounce many species of prickly pear to be decidedly susceptible to cultivation and highly productive of both fruit and forage under proper conditions of temperature and moisture. It is also true that there are species which thrive under moderate extremes of heat; that, as a rule, they are adapted to conditions of periodical rainfall and thrive where the distribution of moisture is too irregular and uncertain for commonly cultivated crops; that the spines and spicules have been practically successfully eliminated from the plant body in valuable species but not from the fruit; that all of the so-called spineless forms concerning which we have definite knowledge are less hardy, especially toward drouth conditions, than spiny natives; that it is quite probable that by persistent breeding and selection the spines and spicules may be more completely removed and the plant bred to withstand a greater degree of cold; that the plants can be fed together with more concentrated foods with profit; that the fruit is now, in its spiny condition, an important and highly prized ingredient in the diet of the poorer classes of Mexico and Sicily especially; and that highly prized products are prepared from the fruits; that the group is of sufficient economic promise to merit thorough investigation.

### The Common Name

The common names which are used in this bulletin have been selected with the utmost care. They are based upon a careful investigation of all of the important prickly pear regions of the United States and Mexico. Unless otherwise indicated, it is believed that they are accurate. In each instance, unless the name is questioned in the text, it has been

verified many times. The orthography of the common names has, in nearly every case, been verified by educated Mexican gentlemen as well as by our own ideas based upon their derivation. We are much indebted to Sr. Enrique L. Guerra for suggestions and corrections of our list of popular names as well as for much valuable information upon all phases of the subject.

The popular names are, as a rule, quite the same in one locality, but there may be great variation when one compares names of species in different localities. Some well marked species, however, have apparently the same name wherever found. The names cardona, taponá, camueso and amarillo are, so far as our experience goes, invariable; but, as stated, they are very characteristic species which even the least observant can not well mistake. It is entirely different with the yellow or green fruited forms (including the tame or cultivated ones). These have a multitude of names by which they are known. Some of them may and probably do represent good specific distinctions. On this point we can not yet be certain, as our experience with the different forms has not been extensive enough. Some of them are spiny, others almost perfectly spineless and even in some cases apparently without spicules on either fruit or joint. In general aspect they are all very much alike and the names applied to the different forms do not appear to be at all uniform. To illustrate; some of the names used for the greenish-white fruited forms are as follows: Nopal blanca, nopal teca, nopal paloaltena, nopal fafayuca, nopal Mexicana, nopal Americana, nopal Castilla blanca, while nopal lisa is commonly used, but the latter name is applied to any thornless form. They all appear to be closely related to one form of our southwestern "mission pear", although with us this is nearly always a thorny form, while the greenish-yellow fruited forms of Mexico may exhibit any degree of spininess.

It must be understood that any list of common names of Mexican tunas can only be of tentative value after all, for there may be even less uniformity in popular names than in this country. In one locality, however, the name used for one species or variety is reasonably constant. The commercial

spirit has no influence here in a change of names, but the use of any name has come about by general custom.

As with many other natural and agricultural subjects, it is the native peon who is the court of final resort upon the names of plants. The ranchman when asked regarding the matter will almost invariably put the question to one of his more intelligent servants. The names used here have been obtained mainly from the peons and have subsequently been verified and examined by educated and intelligent ranchmen.

### **Cultivation of the Nopal**

There are in Mexico many varieties of prickly pear which are found only in cultivation. This is especially true of the spineless forms in general. Others are native and may or may not be cultivated. Of the first group the peon may speak collectively as *mansas* or tame forms, but he has names for all of the varieties which are grown in his orchards as well as for the wild ones of the mountains.

To say that any of the forms are cultivated as we think of cultivation in this country, however, is a gross error. They are rarely ever cultivated. Cuttings are put into the ground and surrounded by a fence to protect them from animal depredations. Aside from this they get little or no cultivation.

A plantation is always started from cuttings, consequently it is an easy matter to maintain uniformity in the quality of the stock. Inasmuch as it is always an object to get tunas as soon as possible—the stock-feed side of the crop being always a secondary consideration—cuttings of three joints are planted when possible. A cutting consisting of two and one-half joints is common. When planted in this way it is said that a crop of tunas is produced the third year, while it takes five years to get one from one-joint cuttings.

Plantations are not confined to the *mansas*. On the contrary, the wild forms will often be found in the orchards under protection and are even planted without protection in the hills. Such forms as the *cardona* are admirably adapted to this purpose, for animals can not molest it much. The thickets of this species east of San Luis Potosi have been



greatly extended by planting cuttings in unoccupied areas. Several acres were planted there last year in this manner. How much of this has been done in the past is difficult to say for it is not always easy to tell the difference between areas which have been planted and those which have not. Quite likely many of the thickets found in the hills have been in a measure, established by the influence of man, some of them unwittingly, for the method of collecting the fruit scatters joints about, many of which strike root and grow. Some of the thickets in the vicinity of Alonzo, Mexico, are being slowly extended by this method of collecting the fruit.

### The Tuna Markets

A very distinctive feature of the markets of the different cities of the highland region of Mexico is the space or booths assigned to the sale of tunas. The business is generally carried on by the poorer population in the most simple and primitive way. Not that the poor are the only ones who eat them, but they are eaten more extensively by the poorer class than any other. Plate III, Fig. 1, gives a good idea of the appearance of the tuna markets.

During the greater part of the season purchasers come to these booths, separated entirely by the size of the individual awnings or length and number of the benches and stools, where they may purchase one or more varieties of fresh tunas at a very low price. The purchaser is supplied with a stool, upon which he can sit, and a knife with which to peel the tunas. During the height of the season, when the fruit is cheapest, women appear on the markets each morning with huge baskets of them ready peeled, which they place in earthen saucers, and dispose of for one cent each (cover page). Each purchaser is furnished with a tip of maguey leaf or a thorn of the mesquite with which to eat the pulps, or, in a few instances, we have seen modern wooden toothpicks served with them.

By far the greater amount of fruit is sold unpeeled. This is especially true during the season when fruits are not abundant, for less waste attends it. Sometimes the purchaser

peels the fruit himself and at others he eats it as the vendor or his attendant peels it for him.

The process of peeling is practically the same as described beyond, the knife being run across the top and down one side to the base, when the pulp may be picked out easily. When fully ripe much of the rind of some species is consumed with the pulp. When this is done the tuna is taken between the thumb and forefinger of the left hand and the rind cut off with a sort of whittling motion of the knife, each stroke taking off the epidermis and a portion of the rind. In reality, not over one-half of the rind is ever eaten. In peeling the larger *mansa* (cultivated) forms, both ends are usually cut off and an incision made through the rind lengthwise between these two cut surfaces, when the remainder of the outside is removed by being pushed back with thumb and forefinger of each hand.

To remove the spicules, so that the fruit can be more easily handled, the vendors employ several simple devices. Sometimes the tunas are rolled around upon the sand by the aid of a bundle of small twigs or a bunch of weeds. At other times they are removed with a wisp of grass or brush made of maguey fibers. Often they are stirred in a pail of water. Any of these processes will remove the spicules fairly well if the fruit is thoroughly ripe. It should be remembered that there are no prickly pears without spicules. Even the so-called thornless ones, which have been developed in the Mediterranean region and eight or ten of which have been apparently produced in Mexico, all have some spicules upon the fruit, although the spines have been quite effectually bred off the plant body. Also, in nearly all cases, there are produced upon the fruits hair-like, fugacious spines, most of which drop off or are easily removed when the fruit is ripe. The spicules are the most serious obstacle to the use of this fruit.

As stated above, it is the pulp which is usually eaten; less often some rind is also consumed with it. It is well known that the pulp itself is very seedy, and on this account objectionable to the average American, although the Mexican swallows seeds and all with apparent indifference. Both the pulp and rind of *cardona* and *durasnilla* are eaten late in the sea-

son. In the latter fruit the pulp is not easily separable from the rind, but in the former it is.

The price of tunas upon the market varies greatly with the season. During the past year the cheapest were found at San Luis Potosi, where the cardona is sold as low as 15 to 20 for one cent\* and the large mansas as low as 6 for a cent. In Guadalajara where tunas are rare, 3 to 5 cardonas for one cent and one amarilla, naranjada, or other mansa for the same price was the rule. During the month of August cardona was selling at San Luis Potosi for about 45 to 50 cents per crate of a thousand tunas wholesale; at the same time they were sold upon the market at the rate of 14 for a cent. It is said that one man can pick about three crates a day.

An attempt was made to determine how much of this fruit is eaten by the average peon in a day, but with no satisfactory results. We have repeatedly seen men eat 25 to 50 without stopping, and have had peons tell us that they eat on an average of about 100 per day. We believe, however, that where the diet is made up largely of tunas and they are conveniently at hand, upward of 200 per day are consumed by one individual. We have had intelligent and conservative ranchmen estimate to us that a man will easily consume many more than this of tuna cardonas per day when in the hills where practically no other food is available. This represents very often in the largest measure both food and drink, but it seems like a very heavy ration when one considers that the seeds as well as the pulp are swallowed. It has been our experience that one not accustomed to the fruit can eat 60 to 80 tuna cardonas and not swallow the seed. We have done this on one or two occasions in about two hours time.

It must be remembered that the pulp of 40 to 50 tunas (cardona) forms quite a bulky meal; the seeds are, of course, not digested. It is claimed that only a few of the species can be eaten in large quantities without danger. There is said to be no danger at all from eating any number of tuna cordonas, unless it be immediately after a heavy meal consisting largely

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\* Unless distinctly specified to the contrary, the prices quoted are in Mexican currency. U. S. equivalents can be obtained approximately by dividing by 2.

of meat. On the contrary, it is claimed that the mansas must be partaken of sparingly on account of their interference with digestion when eaten too freely. A peon is quite careful in eating tuna tapona because he believes it produces intense constipation. They claim that death has resulted in some cases from eating too much of this fruit.

The excreta, both solid and liquid, are decidedly colored when the red tunas, especially tapona, are eaten. So far as we have been able to learn, however, tuna cardona is the universal favorite and apparently results in no injury whatever, even when partaken of very freely. The natives' explanation of the injurious effects of the mansas is that they are too rich.

Where there are so many tunas consumed there is, of course, a large quantity of rind, and in the manufacture of "queso" and other products the quantity of seed taken out is quite large. Upon one ranch visited the by-products were fed to hogs. Upon the markets at San Luis Potosi during the month of August, the rinds were selling at the rate of ten cents to twelve cents per basket of about 50 pounds. They were consumed largely by dairy cattle, and were also fed to burros and hogs.

### General Description of the Fruits

The fruits of prickly pear vary in size, shape and color, depending upon the species and conditions under which they are grown. They are from one to three inches in diameter and are usually pear or fig-shaped, but in some species they are nearly spherical. They will weigh from an ounce to a half pound or more, and vary when ripe from a yellowish-green to a dark purple color.

All varieties have minute spicules arranged in bunches over their surface, there being about one bunch to every square inch of surface in the best varieties, but in most species they are more numerous than this. The fruits of nearly all of the species have large spines also, which correspond to those of the plant body, but they are much more delicate and usually drop off before the fruits are thoroughly ripe. A cross section through the fruit shows it to be covered with a thin skin

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Collector's Number

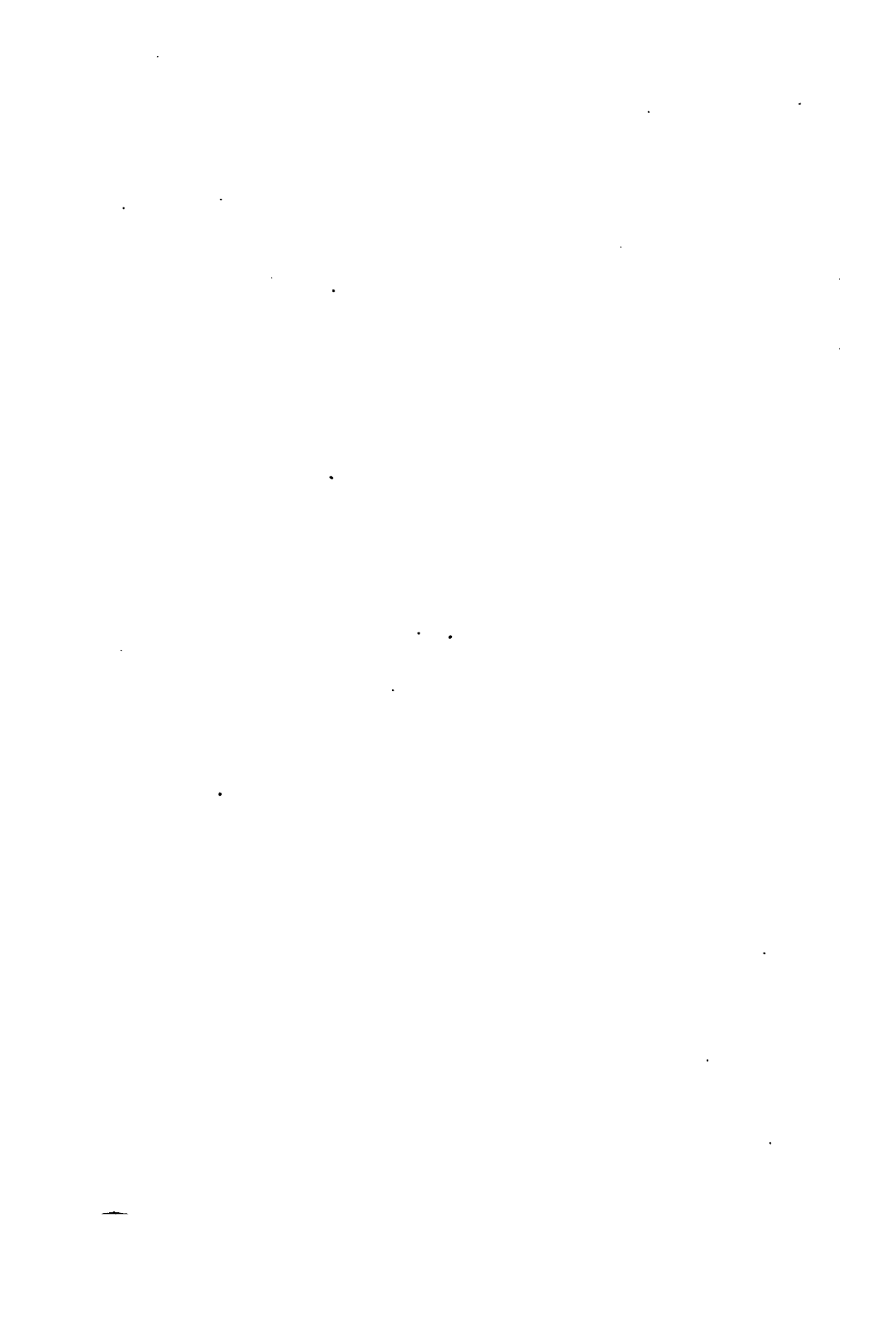
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Average

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8050  
8050a+  
8050b+  
8050  
8050a+  
8050b+  
8143  
8150  
8545  
8146  
8547  
8141  
8546  
8057  
8485  
8142  
8140  
8135  
8134  
8119  
8102  
8100  
8136  
8035a  
8035b  
8050

Average

8035  
5





or epidermis, underneath which there is a rind varying in thickness from  $\frac{1}{8}$  to  $\frac{1}{2}$  inch. This includes the pulp or edible portion in which there are found imbedded from 100 to 200 or more seeds. In some fruits we have counted as many as 400.

#### The Epidermis

The epidermis is the thin outer skin, and whether the fruits are eaten raw or in conserved products, it is necessary that this be removed because of the tiny spines occurring in bunches over its tough, leathery surface. When the fruits are peeled, this portion constitutes a part of the waste together with a small part of the rind which it is necessary to remove along with it.

#### The Rind

The fruit itself is found enveloped in what is morphologically a portion of the stem, which we have called rind. It partakes of the nature of both fruit and stem, usually assuming the color of the fruit and somewhat approaching it in composition. In some varieties it contains sufficient sugar to make it edible, but it usually retains so much plant mucilage, always present in the stems, that it is not as palatable as it would otherwise be. With the exception of the formation of some sugar as the rind ripens, and the change in coloring matter, the rind retains the general cell structure and appearance of the stem.

The rind is usually easily separated from the pulp. It constitutes from 25 per cent. to 75 per cent. of the fruit, and when this is not eaten there is of course a very large percentage of waste. Consequently the fruit which has the thinnest rind is the most desirable.

In a number of species where the waste was large and the rind at all palatable, a separate analysis was made of this to determine its nutritive value compared with the pulp. The results are given in Table No. I. By comparing the results there given with the analysis of the pulp in Table No. II, it will be seen that the total and soluble solids of the pulp are both more than that of the rind. In fact, about 50 per cent. of

the solids of the rind are in an insoluble form, whereas in the pulp the solids are almost completely soluble. In the rind the acid is always comparatively high, as is also the alcohol precipitate, both of which make the fruits unpalatable. The specific gravity of the juice of the rind is always less than that of the pulp, and the sugar content is also much less. The results of our analysis show that the rind at times contains some sucrose which seems more often to be lacking in the pulp.

#### The Pulp

This is the edible portion of the fruit and is the portion that is eaten in all varieties. In some species it is insipid, but in many it has an excellent flavor. We believe that Americans will acquire a liking for this fruit more readily than they do for tropical and sub-tropical fruits in general. The amount of pulp in the different varieties varies from 30 per cent. to 65 per cent., and as a rule those with a large percentage of pulp have the best flavor.

The structure of the pulp is rather peculiar for a fruit. The walls of the cells are very thin, and there is consequently but very little fibrous substance in its make up and indeed but little insoluble solids in the majority of the species. By pressing the pulp in muslin bags practically the entire amount can be forced through the meshes of the cloth. This was found to be the most satisfactory method of separating the seed from the pulp and was the one adopted in our analytical work. The small amount of fibrous tissue is shown by the amount of insoluble solids which averages less than one per cent. for all the samples.

There is a great variation in the composition of the pulp of the different species, and, of course, for even the same species at different seasons or degrees of ripeness. The amount and character of the edible matter varies a great deal in the different samples, as will be seen when the different constituents of the edible portion are discussed. Several varieties have been worked in duplicate and by referring to the tables it will be seen that very often the two analyses are very different. This may be accounted for in several ways. In the first place, the fruit may be eaten in very different degrees of ripeness.

The pulp of tuna tapona, for instance, is palatable at least two weeks before the outside of the fruit turns red and is commonly eaten from the time the pulp turns red until the outside is a deep purplish color. The time which it takes for these changes to occur in the fruit is not less than a month. Browne\* has found that apples, and Bigelow\*\* that peaches vary a great deal in composition during their different periods of growth, and in all probability the same would be found true of fruits of the cacti. The season, climatic conditions, and soil fertility no doubt affect the composition of this fruit as they do all others.

#### The Seed

The seed are distributed (Pl. III, Fig. 2) throughout the mass of the pulp. They are somewhat disc-shaped, and are from 1/8 to 3/16 inches in diameter. The seed coats are very hard and are never masticated or digested when the fruit is eaten. Each fruit contains a large number of seed, varying somewhat with the different varieties. Some of the samples analyzed had not to exceed 75 seeds, while others had as many as 400. The average weight for the wild forms from Texas was 7.54 per cent. of the whole fruits, while in one of the Mexican samples of cultivated varieties there were only 1.52 per cent. of seeds. The larger cultivated fruits always have proportionally fewer seeds, and it may be that in time cultivation and selection would still further reduce the number.

#### The Refuse

The waste in eating the cactus fruits is the sum of the weights of its seed and rind, if the latter is rejected; when the rind is eaten, the waste is the seed with only that part of the rind which is lost in peeling the fruit. Since such a large percentage is rind, the waste is very large when this is rejected. In one variety, tuna chavena (No. 8136), it amounted to 78.17 per cent. The fruit having the smallest amount of waste of all the prickly pears was No. 8142, tuna naranjada, it having only 37.45 per cent. The average for the Mexican

\* Penn. Dept. of Agriculture, Bulletin No. 58.

\*\* U. S. Dept. of Agriculture, Bureau of Chemistry, Bulletin No. 97.

samples was 56.18 per cent. The samples received from San Antonio, Texas, (*O. lindheimeri*) averaged 71.56 per cent. refuse.

The watermelon has 59.4 per cent. waste; the muskmellon, 50 per cent.; bananas, 35 per cent.; oranges, 27 per cent.; apples, 25 per cent.; pears, 10 per cent.\* Thus it will be seen that the tunas have about the same amount of refuse as the melon when the rind is rejected, and about the same as other fruits when it is eaten.

### Harvesting the Tuna

The method of harvesting the tuna is influenced both by the variety gathered and the purposes to which the crop is to be put.

#### Harvesting for Immediate Consumption

It is common for the peon to get a large portion of his living during the tuna season from the plants as they stand in the field. A large part of the crop is therefore consumed directly from the plants. The object of the picker in such cases is to get the edible pulp separated from the remainder of the fruit with as little difficulty as possible. A sharp knife is used to make an incision across the top of the fruit and curving down on one side to or nearly to the attachment. Then the thumb and forefinger of the left hand are forced down between the rind and the pulp, loosening the latter and forcing it upward, when it is caught between the thumb, index and middle fingers and removed without coming in contact with the small spines at all. The incision is made to such a depth as to just expose the pulp and none of the rind is removed from the plant. Of course this method applies to only such fruits as are in reach of the picker and is practiced by those who eat as they gather in the field. The method of securing the tunas growing beyond reach of a man standing upon the ground is described beyond.

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\* U. S. Dept. of Agriculture, Office of Experiment Stations, Bulletin 28.



**Figure 1.—Gathering Tunas for Immediate Consumption.**



**Figure 2.—Peeling Tunas for Immediate Consumption.**

**PLATE II.—Harvesting Tuna Cardona.**



Figure 1.—General View of a Tuna Market.

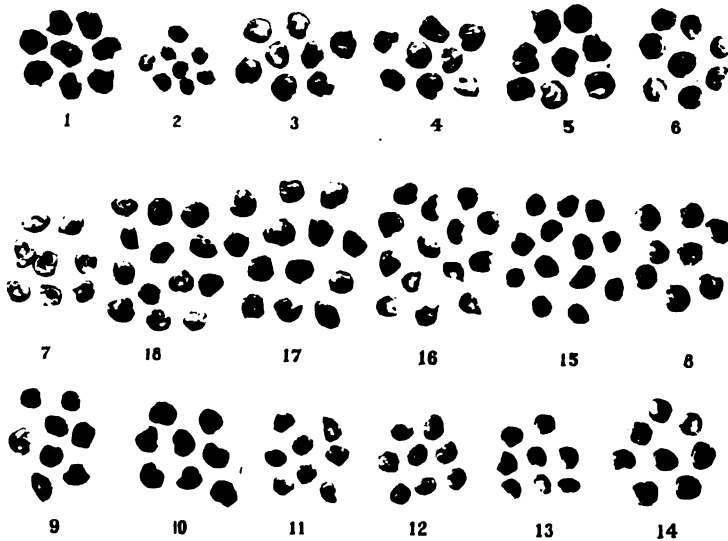


Figure 2.—Seeds of Edible Tunas (natural size).

### Gathering Cultivated Forms

As stated elsewhere, the mansas or tame forms are not disfigured by cutting the joints as are the wild ones described beyond. The vast majority of the cultivated tunas are produced beyond the reach of a man on the ground and they are therefore collected with a long (usually bamboo) pole. The end of this pole is divided into three or four equal segments which are held apart by a wooden plug secured firmly in place by thongs of rawhide or maguey (*Agave*) fiber. This makes a conical receptacle in the end of the pole which is thrust around the tuna, the latter being removed by twisting the pole. In this process of gathering, the fruit is more or less injured either by the end of the stick itself, or by the wrenching process used in loosening it from the tree. Sometimes the fibers entering the tuna from the joint are twisted off, leaving a lacerated hole in the end of the fruit. At other times the base of the tuna itself is twisted off. It is evident that fruit injured in this way will not keep long. A large part, however, of the fruit of the cultivated forms upon the markets is gathered in this way.

### Gathering Wild Forms

(See Plate II.)

Whenever the preservation of the plants is not an important consideration, the Mexican gathers the tunas which are beyond his reach with a gancho (hook) made by fastening a strong knife blade at right angles to a long pole. With this he cuts the joint nearly off, thrusts the point of the gancho into the severed joint and lowers it to the ground. Commonly but very little attention is paid to the quantity cut from the plant, the place of the incision depending upon the number and distribution of the tunas. Often two or three joints are taken off together, but more commonly only that portion of the one containing tunas.

After the joints have been lowered to the ground in this way, the pulp is removed as described above under "Immediate Consumption", the operator either standing in a bent-over position with one foot upon the segment of joint or kneeling upon one knee.

### Gathering for the Market

When tunas are desired for the market, for shipment or for storage in a fresh condition, more care is exercised in picking them. Instead of tearing or twisting them from the joints, they are carefully cut off with a sharp knife. The fruit is taken between the thumb, fore and middle fingers of the left hand, pushed to one side slightly, when, with the point of a knife, its connection with the stem is severed. The difficulty of this operation may not be apparent to the reader unfamiliar with the small spines with which the fruits are protected. The handling must be very carefully done, and the native becomes so adept that he grasps the fruit between the cushions of spines with much less likelihood of being injured than the novice. Owing to the fact that there is no appreciable fruit stock as there is in the apple, peach, or pear, it is difficult to remove the fruits from the trees without injuring them. Italian shipments upon the markets of this country usually have a small portion of the joint attached to the fruit. It is usually less difficult to collect in this way, but the small piece of joint probably has no advantage over a perfect fruit removed without it. The difficulty of picking without injury varies with different varieties and in the same variety under different conditions of development. A plump fruit is much more difficult to remove without injury than one which is shriveled, as will be readily apparent. Such forms as the amarilla, naranjada, camuesa, etc., which assume more of the shape of the common pear, are more easily picked than the more nearly globular forms such as cardona, chavena, etc.

### Comparison of Different Methods of Harvesting

Personal observations of the thickets, and the opinions of the more intelligent people, lead us to believe that on the whole cutting off the joints results in injury to the succeeding crop of tunas. Fruits are produced upon the last year's growth, and if this be very severely pruned, as is often the case when a large crop is harvested with the gancho, the growth the following season is very largely vegetative joints and not fruits, but the second year after the severe pruning is likely to produce a large crop of fruit again. In fact, the pruning is not



wholly bad, for the joints strewn over the ground often give rise to new plants, thereby extending the thickets.

### Keeping Qualities of Tunas

Contrary to popular opinion, some tunas can be preserved in the fresh condition about as long as the common fruits of the temperate zone, if properly handled. It is not at all uncommon to find the Italian forms upon the markets of the chief cities of this country in the fall and early winter. These withstand the transportation, besides two or three months in storage on this side of the ocean. The writers have had samples of yellow tunas of Italian origin secured upon the markets in Washington City remain in good condition in their possession for two months while subjected to the irregular temperatures of an ordinary living room.

Like all other fruits, different forms have different keeping qualities, and freshness is of longer duration when the picking is done before maturity than when dead ripe. Tuna cardona will remain good for from twelve to fifteen days upon the open markets of Mexico, after being picked and packed on burros a distance of ten or twenty miles. The mansa forms keep longer if cut instead of being twisted or pulled off. The best keepers are, without doubt, some of the forms of joconoxtle and chavena. The latter is the one commonly kept over winter in the region of Aguas Calientes. The packing of this species is a regular business and it may be found upon the markets as late as the first of May. It is one of the latest to mature in the fall and has a comparatively thick, firm rind, well adapted to being stored. On the whole it may be said that tunas are easily injured and consequently much care is necessary in handling them when they are intended for packing. They must also be well aerated in storage, which is true of all fruits.

At the present time there is quite an extensive shipment of tunas by mail from place to place in Mexico. One of us happened to be in Torreon one Sunday last September when a carload was brought from near Aguas Calientes. It contained cardona mostly, but also some fafayuca, amarilla, naranjada, and durasnilla. They were shipped loose in an ordinary box

car, piled upon the bottom of the car to a depth of about two feet. They are commonly shipped packed in crates with straw, the crate being usually a little smaller than our common orange boxes.

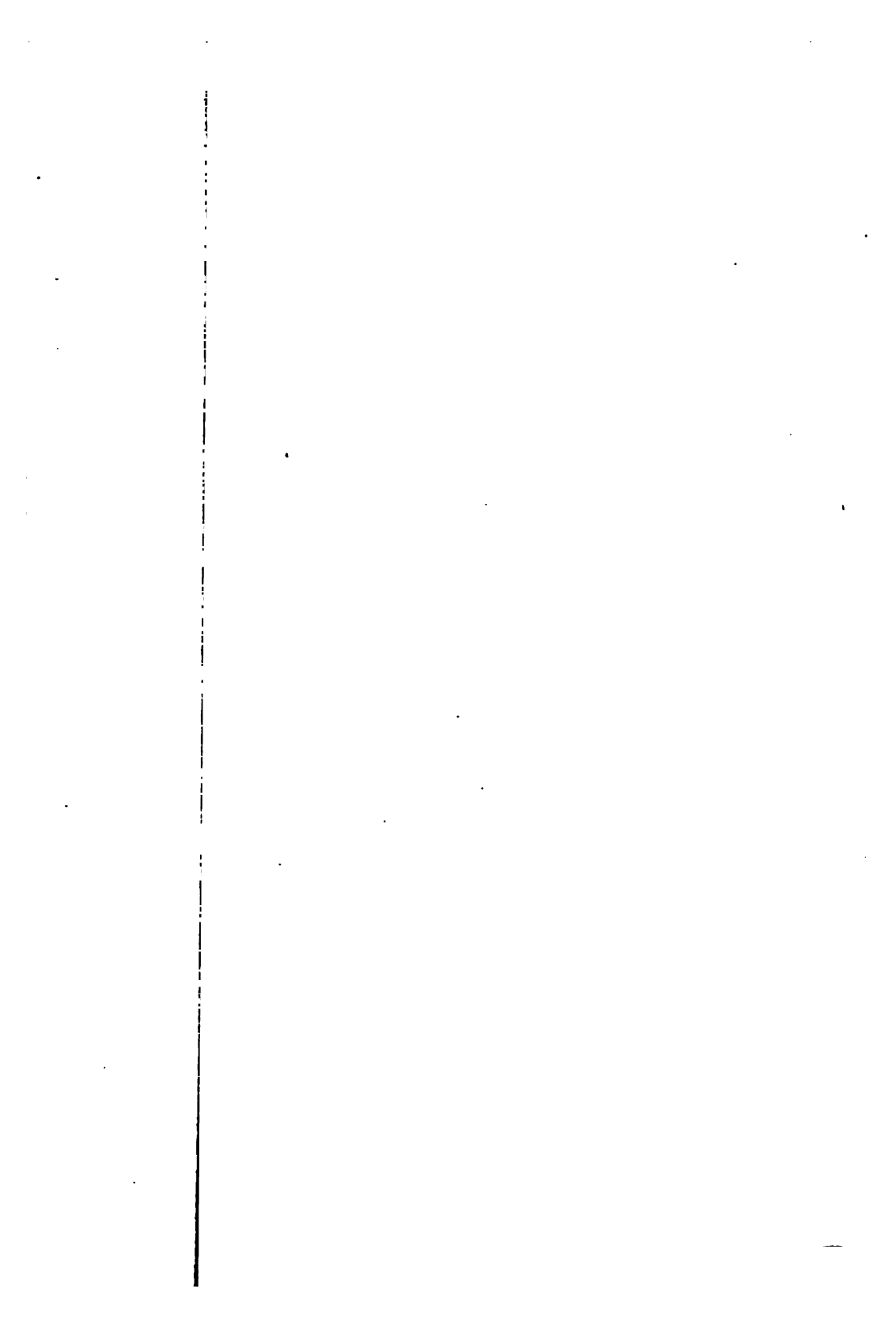
They are usually brought to market in crates packed on burros. When intended for immediate market use they are emptied in piles upon the ground, those not actually in use being covered with green herbage or old cloths and kept at a lower temperature than the surrounding atmosphere by the evaporation of water sprinkled over them from time to time. Handled in this way they keep in the open air for ten to twenty days.

Some species, chavena especially, in the vicinity of Aguas Calientes, are regularly kept over winter in the fresh condition and one may find some of the various species and varieties upon the market places practically the entire year. From late May to early December there are fresh forms constantly found and even in the spring some of the forms of joconoxtle, which are eaten only after being cooked, may be found upon the trees. However, the majority of those upon the markets after December have been packed. Around Aguas Calientes these are almost invariably chavena which have been put in storage. They are spread in thin layers, alternating with layers of straw or old hay in a dry aerated situation. Handled in this way they will keep from October or November to the first of May.

### Tuna Products

Of the numerous products manufactured from the prickly pear only those which appear to us to be the most important have been selected for discussion. To consider all of the products would necessitate more space than can be devoted to the subject. Those enumerated will give a very fair idea of the importance of the crop upon the high lands of Mexico.

In detailing the methods of manufacture, it is realized that the descriptions given constitute simply the recipe used by the people in a certain locality. There may be variation in the methods employed in different sections, but the essential fea-





tures of the processes do not differ. The methods here outlined are those employed in the vicinity of Villa Garcia in the State of Zacatecas.

The tuna products are usually manufactured in the season when the fruit is thoroughly ripened. At any other time the business would not be as profitable, because the labor of collecting would be much greater if it was done while the crop was only partially ripe. Again, there is less need for preservation of the valuable material so long as it remains in good condition upon the trees and may be eaten in the fresh state.

In the different manufacturing processes all available tunas may be used indiscriminately, but there are certain characteristics essential in certain products. However, the pickers usually gather all fruits of whatever species they can find, but the prevailing material will be of one species usually best suited to the process.

The tunas may be divided into two great classes, based upon their condition when ripe. One group or class has pulp which, when squeezed through a fine cloth, gives a limpid liquid with most of the solid constituents in solution. To this group belong the more important of the mansa or cultivated forms, such as amarilla, naranjada, blanca, palo alena, fafayuca, camuesa, ranchera, and morada. The other class has fruits whose pulp when treated in the same manner yields an opaque liquid having much solid matter in suspension in a fine granular condition. The foremost of this group is cardona and with it should be classed taponá, agua-mielilla, leonera, pachona, and opalilla. For the manufacture of queso, melcocha, and miel, only those forms are used which have solid or semi-solid substances in suspension in their extracted juices. The members of the other group are more often used for drying.

Colonche may be manufactured from almost any of the species, but as a matter of fact it is seldom made from the mansas because of the higher value of the fresh fruit. In practise the species used in a locality is quite constant, and the products manufactured are quite pure, for one species usually predominates to such an extent as to necessitate its use to the exclusion of others. For instance, in the vicinity of San Luis

Potosi and Aguas Calientes the cardona predominates, while farther south leonera, agua-mielilla, or artona are more prevalent. It is not economy to prepare the products from the large mansa forms until late in the season, and then they are usually dried. They command a better price fresh because the supply is rather limited.

Different colored species produce products of different color, as would be expected. The color for a given product from any species, however, may or may not be constant, for the process of manufacture may vary to such an extent as to change the color. This applies especially to such products as miel, melcocha and queso, which have a somewhat complicated process of manufacture, are subjected to a considerable heat, and, in the case of the last named especially, are modified by aeration and kneading after the boiling ceases. The boiled paste from tuna cardona is almost black, and melcocha is consequently of the same color, but the queso is light brown. Tuna taponá, on the contrary, retains its red color through the boiling process, and consequently makes red queso which does not seem to be in much favor.

When tunas are gathered for manufacturing purposes the pulp—the part ordinarily used—is removed in the field as described elsewhere. On account of its exceedingly juicy nature it is gathered in earthenware vessels or ollas (o-yas) and taken into the factories in fifty to seventy-five pound lots. The picker usually has the earthenware vessel strung across his shoulders by means of ropes of maguey (*Agave*) fiber. When the vessel is filled, it is delivered to the factory either in a cart or by the picker himself if the factory is not too far away. Material delivered to the factories consists of the seedy pulp which is ready for the kettles or the seeders.

#### The Machinery Used in Making Tuna Products

It is scarcely necessary to state that all of the appliances used in the manufacture of tuna products are of the most primitive nature, simple and crude, but still often exhibiting a great deal of skill and ingenuity in the use of inexpensive materials at hand which might not be recognized as at all suitable by more highly civilized people. It must be remembered that the

processes described here are essentially those of the primitive peoples of the Republic. They are processes which have probably been followed in all essential particulars since Cortez first landed, and how long before no one knows.

It is a common practice for a suitable number of people to establish a camp in the prickly pear thickets late in the season for the purpose of manufacturing queso and the other products. A factory and a few rude huts are quickly thrown up, giving shelter to the workers as well as to the manufactured products. Factories which we have seen consist of a small adobe building of one room about twenty-five feet long by fifteen feet wide, thatched with the leaves of the yucca. (See Pl. VII, Fig. 1). They usually contain one or two kettles, usually of copper although pottery is sometimes used, one or two troughs hewn out of willow, three or four earthenware tubs, and smaller earthenware vessels with which the liquids and plastic materials are handled. The kettles are set in the ground up to their handles on a slightly elevated side of the room, over a rude furnace consisting of earth, rock, and adobe. The essential machinery is fairly well represented in Pl. VI, Fig. 2. Besides the kettles, there may be seen in the rear of the room two seeders of tin, supported upon a frame and shown in more detail in Pl. V, Fig. 1. On the left of the factory is seen a large trough hewn from the trunk of a willow, and in the rear of the room is another smaller one of the same material. Under the seeders are seen earthenware tubs. The bottom of an olla (earthenware urn) projects above the first kettle. The kettles are reinforced to a height of about eighteen inches by slabs of wood cut from the trunk of a large yucca. These are tightly fitted together, and the whole tied with a rope made of agave fiber as shown in Pl. VI, Fig. 2. Some of the yucca wood is macerated and used to chink in around the top of the kettle to make it tight. The kettles are about twenty inches deep and three and one-half feet in diameter.

The seeder consists of a tin vessel with a short conical base having a pivot support in the center to receive an axial shaft upon which are hung paddle-like wings, shown in more detail in Pl. V, Fig. 1. This axis with the paddles is operated by a

crank, as shown in the illustration. The tin vessel is perforated by nail holes of such size that they will not allow the seeds to pass.

The furnace is exceedingly crude. It consists of a fire pit under the kettles, and somewhere a smoke flue. Pl. VI, Fig. 1, shows the outside of the right of the room shown in Pl. VI, Fig. 2. The center holes shown are the two orifices through which fuel is fed into the furnace. The other two openings are the smoke flues, but as a matter of fact, in this particular instance the doors act as the principal smoke flue, as is plainly seen, by the deposit of soot upon the wall shown in the picture.

#### Miel de Tuna

In the manufacture of this product the seeder is usually not employed. The peeled tunas are put in the kettles and boiled until the free seeds fall to the bottom. This occupies usually about two hours, fresh material being added from time to time as the water evaporates. The seeds are removed with a sieve and the sirup returned to the fire and boiled slowly for two or three hours more, or until it approaches the consistency of honey. It is then poured into wooden troughs where it is thoroughly mixed with wooden paddles until completely cooled. After setting for twelve to twenty-four hours it is packed away in bottles or earthenware jugs. It may be kept about the same as molasses, and is said to remain in good condition indefinitely. After a time, however, it candies and becomes difficult to handle.

The method of cooling is considered very important in the manufacture of this product as well as in the manufacture of melcocha and queso, for if the material is allowed to cool without stirring it is said to have a tendency to sour. After it has cooled there is said to be no further danger of deterioration. The only change which appears to take place thereafter is crystallization which begins rather soon and is said to continue for a couple of years until a completely candied mass is formed. Upon the large haciendas away from town this sells for from fifteen to twenty cents a liter (about one quart).



### Melcocha

In the manufacture of melcocha peeled tunas are put in the machine and seeded. The kettles are filled two-thirds full of juice, which is boiled with a brisk fire for about three-quarters of an hour, when more juice is added and the boiling continued. The foam arising from the boiling is very great when the sirup is thin, but as it thickens this becomes less, and more of the fresh juice is added to thin it until, little by little, the supply is all used up. This takes four or five hours in all. The material is then kept warm by banking the ashes. After this it is kept in such a condition that it thickens very gradually for one or two hours more, the object now being to keep the evaporation constant and low, until the proper consistency is reached. When a spoonful can be dipped up and the material will not run out when turned upside down, the process of evaporation is stopped, and all fire removed from the furnace.

The processes for the manufacture of melcocha are exceedingly variable. The one detailed above is that interpreted to us by Senor Enrique Guerra in 1905. In 1906 other persons upon the same hacienda were preparing melcocha somewhat differently.

The puddled paste from which queso is made is also called melcocha, and often this is preserved for future use with no kneading or other preparation except packing away in suitable receptacles as described elsewhere. The only difference between melcocha and queso in that case consists in the kneading and puddling which the paste gets after being cooled, the melcocha being simply unkneaded queso. We might liken the two products roughly to taffy in the different stages of its manufacture, the taffy corresponding to the queso, and the cooked sugar or molasses before being pulled to the melcocha.

The melcocha is then poured into a trough as in the case of miel, and worked with wooden paddles very rapidly, in order that it may cool as quickly as possible. When the temperature is reduced so that it is not uncomfortable to the touch, the vessel is covered and left until the next day, or it may be left two or three days. The best way, it is said, is to puddle upon a stone or wooden table twenty-four hours after evapor-

ation has ceased. The rule here is to "strike" the "dough" one hundred times on a stone, the whole lump being raised above the head and then dropped forcibly one hundred times. During this process flavoring matter, almonds, etc., are sometimes added to the product, but usually nothing is added to the concentrated juice.

Crystallization begins in melcocha within a month or six weeks after manufacture and continues indefinitely, the material becoming more and more candied with time, like miel.

Melcocha may be kept in earthen jars with wide mouths, which is the common method of preservation. Another poorer way is to preserve without puddling. In this case, about two tablespoonfuls is put in a corn husk and covered completely and as tightly as possible with this kind of covering. In this form it is a common article upon the market places in the larger cities and this quantity usually sells for one cent. The price of melcocha put up in quantity in earthenware jars is from \$1.50 to \$2.00 per aroba (twenty-five pounds).

#### Queso de Tuna

The queso, or cheese of the tuna, is made the same as melcocha, except that the evaporation is carried a little further, until the cooled material will not "leave the spoon" when it is shaken. The puddling is also more thoroughly done. The rule here is to "strike" one hundred and fifty or two hundred times upon a flat stone or wooden table. This, although so similar to melcocha, never crystallizes, although the evaporation is carried but little farther.

After puddling, the product is put in any shape desired. It is commonly shaped in small hoops of white pine or willow about three inches in diameter, or in larger boxes dove-tailed at the corners so they can be removed in pieces. The first method gives the product the form of the common cottage cheese found upon the markets, and it is from this that it receives its name, "Queso de tuna", or cheese of the tuna. These molds are moistened just before the material is packed into them to be shaped. They are then removed immediately. The queso sets perfectly in from one to two hours. It is a

common practice at the larger haciendas, where a first class product is desired, to cover the queso with tin foil to preserve the color and prevent evaporation. No other changes appear to take place in this product.

Queso will keep indefinitely, if put away in a dry place to prevent moulding. However, it gets harder and harder from loss of moisture as time goes on. Covering with tin foil delays hardening and prevents darkening to some extent. The more puddling or kneading the material gets in its manufacture the harder it becomes, and the lighter is its color. To avoid the labor of puddling it is a common practice to get rid of the natural dark color by adding dyes. This leaves the queso soft, and gives to the trade the color that is pleasing. Beet, carrot, and other vegetable juices are used for this purpose.

Sometimes one will find queso and melcocha packed in vessels in alternate layers. After a few months the melcocha is candied to a considerable extent, while the queso remains soft and plastic, giving what is considered a very desirable product.

The treatment of the paste after leaving the kettles is one of aeration, and does not differ essentially in effect upon the products from the process of pulling taffy. Although it would seem that the details of the process might be very varied, wherever we have observed queso puddled the method has always been the same. A batch of the paste consisting of from ten to twenty pounds is placed upon a flat rock which has been previously moistened with water. The paste is gathered into a compact mass by hand and the whole raised above the head of the operator and dropped, or, really, thrown forcibly down upon the rock again. The edges of the flattened mass are gathered together again and the process repeated many times. Usually two persons work in relays, for the labor is very exhausting, the mass of paste being quite heavy, and the movements necessary being quite rapid and vigorous to handle properly.

#### Colonche

In the preparation of colonche, which is a fermented drink, the pulp, including the seed, is boiled slowly two or three hours, fresh material being added from time to time as evapo-

ration goes on. The whole mass is then strained, and the liquid set away to cool. Usually a little old colonche is added to start fermentation. This beverage is used from the time fermentation begins up to twenty days or more. The longer it stands the more violent is its intoxicating effect. The seeds may also be removed by the seed extractor when the juice is boiled as before. Sometimes, but not as frequently as formerly, old colonche is distilled into an alcoholic beverage. It was a common practice a few years ago to distill the fermented peelings of the tuna, but the practice has not been successful because of the ill effects which the product is said to have. The natives say it produces violent headaches, and for this reason is almost entirely supplanted by mescal, tequilla, and other maguey (*Agave*) products which produce less deleterious effects.

No successful method seems to have been devised for the preservation of colonche. Some have tried to bottle it, but without success. It is quite probable that the fresh juice could be preserved by boiling, thus killing all germs, and then hermetically sealing in vessels in much the same way as fresh fruits are preserved in this country. The failures appear to us to be due to imperfect methods of sterilization.

#### Relation of Tunas to Finished Product

It is seldom that one can get any idea of the amount of boiling and evaporating to which the tuna juice is subjected by talking to the men who make the queso. Fortunately, in 1906, an opportunity was had to visit Los Campos in season. Through the kindness of Señor Enrique Guerra a day was spent at the queso factory, illustrated in Pl. VI, and notes were secured upon the work carried on that day, including the entire process from the charging of the kettles in the morning to the puddling in the evening. The next morning the kneading of the paste was also witnessed.

At six o'clock in the morning of the day spent at the factory the kettles were charged with sixty-five gallons of the juice of tuna cardona, a portion of which had been seeded the night before. A brisk fire was started at the same time, of



**Figure 1.—Peeling Tunas for Drying, Montesa, Mexico.**



**Figure 2.—Drying Tunas in the Sun, Montesa, Mexico.**

**PLATE IV.—Dry Tunas (Tunas Pasadas).**

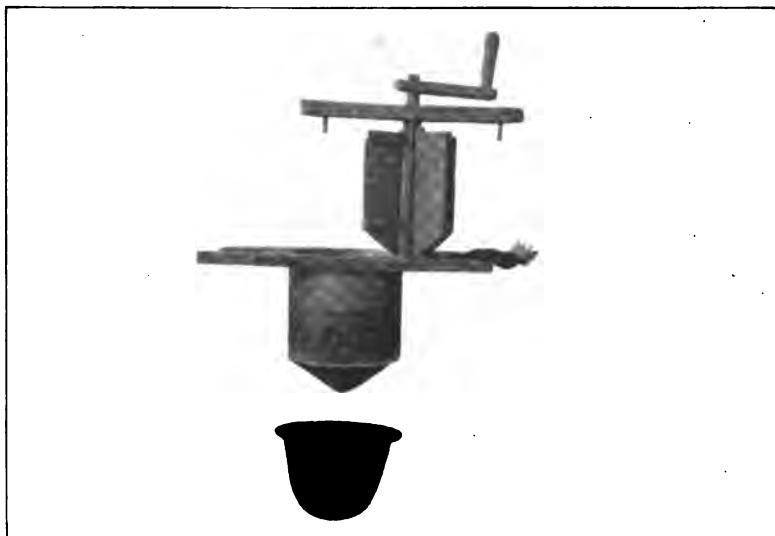


Figure 1.—A Seeder Dissected.



Figure 2.—Nonal Agua-Miehlila, Dublan, Mexico.

PLATE V.—The Nonal and a Tuna Machine.

wood of the same species of prickly pear. During the day twenty-five gallons more of the juice were added as evaporation proceeded. The evaporation was carried on very slowly and somewhat irregularly until eight o'clock in the evening. But little attention was paid to the kettles until toward evening, when the juice was constantly stirred. The juice was secured from one hundred and fifty gallons of peeled tunas from which the rind had been completely removed, the shrinkage in seeding being very largely due to the bulky seed. These, however, we did not have a chance to weigh. The melcocha which was kneaded into queso the next day measured twelve gallons and weighed one hundred and thirty pounds. These figures are accurate within the limits of error incident to working with crude instruments of measure and are accurate enough for ordinary computations upon these processes.

The relation of rind to pulp and seed in tuna cardona as determined by our laboratory investigations is as 42.66 to 57.34. In the above charge of the kettles, therefore, the tunas, if they had been picked in the field, rind and all would have measured about 261.66 gallons, yielding 150 gallons of tunas with the rind removed, which, when seeded, gave 90 gallons of juice. This when boiled gave twelve gallons of queso, weighing one hundred and thirty pounds.

These figures apply only to tuna cardona. The proportions might be very different for any other species, but the amount of queso prepared from any other species is small. Cardona is preeminently the queso tuna. It is a native species of average size, weighing about  $1\frac{1}{2}$  oz. It is only one-half to one-fourth the size of many of the cultivated forms. Of course even with an invariable thickness of rind the larger the tuna the smaller the proportion of rind. The tunas vary in the thickness of their rind, in the relative number of seed, and in the relative amounts of fibrous material in the pulp.

#### Dried Tunas

(Tunas Pasadas. Tunas Secas.)

The native exhibits a great deal of dexterity in the use of the knife in the preparation of the tuna to be dried. The thin outer skin of the fruit is so impervious to moisture that evap-

oration does not take place rapidly, and the fruit dries very slowly until this skin is removed. At the same time, because of the small amount of pulp and large amount of juice, it is not a good plan to slice the fruit as apples are sliced. The plan followed is to peel very thinly, and dry the pulp and rind intact. The tuna to be peeled is grasped with the thumb and middle finger of the left hand and the epidermis literally whittled off with a sharp knife in small pieces almost as thin as paper. The operator saves all of the rind he can, taking off only the thin, tough epidermal covering, together with the areoles containing the spicules. The flower scar is left unmolested to dry upon the fruit. When peeled the fruits are sun dried upon a lattice work of switches tied together with maguey fiber or narrow strips of rawhide. (See Pl. IV, Fig. 2.). The drying occupies from 10 to 15 days, when a yellow deposit consisting probably in large part of crystals of dextrose incased in a covering of gum, plant mucilage, and possibly some uncrystallizable levulose completely covers the outside of the fruit. They are then packed in woven rush bags and in this condition are said to keep quite as well as other dried fruits. An attempt is made to get the outside thoroughly dried, but there is a great deal of moisture left in the pulp. After being packed loosely in a box for six months the pulp is still quite pasty and on the whole little drier than fresh dates as ordinarily found upon the markets. When kept in large quantities, tightly packed, the evaporation is, of course, not as great.

Considerable dexterity is exhibited by the operators in preparing the tunas for drying. We had the good fortune to observe the process in Montesa, in the State of Zacatecas. Pl. IV, Fig. 1, tells better than words the attitude of the operator in peeling tunas. The fruit is held between the thumb and middle finger of the left hand, the thumb resting on the flower scar, and with a sharp knife in the right hand the epidermis is whittled off. The movements, contrary to what one would expect, are comparatively simple, the right hand moving the knife rapidly in one plane, the left holding the tuna between the thumb and middle finger, the index and third fingers rolling it on its axis. It makes two revolutions before it is completely divested of its epidermis. During the first revolution





**Figure 1.—Exterior of Factory, Showing Furnace and Flues.**



**Figure 2.—Interior of Factory, showing Seeders, Evaporation Kettles, Etc.**

**PLATE VI.—A "Queso de Tuna" Factory, Los Campos, Zacatecas, Mexico.**



**Figure 1.**—A Temporary Camp in a Tuna Thicket at Harvest Time.  
State of Zacatecas, Mexico.



**Figure 2.**—First Crop of Tunas in the Second Year From Two to  
Three-Joint Cuttings. (Nopal Mansa Morada). San Luis  
Potosi, Mexico, August 20, 1906.

**PLATE VII.**—In Prickly Pear Thickets.

the epidermis is removed from the upper portion, then the fruit is tilted slightly as it revolves slowly and the epidermis is removed from the lower half during the second revolution on its axis. The knife moves in one place, the tuna being held stationary in the left hand and revolved on its axis by the movements of the index and third fingers, and at about the middle of the process it is tilted on its axis. The epidermis is thus removed in small, very thin pieces. Before being peeled the fruit is brushed, to remove the spicules as described elsewhere. The operator shown in the above figure was timed repeatedly to determine the speed with which he worked. A fruit was peeled with from twenty-eight to thirty-five strokes of the knife, and in the remarkably short space of ten seconds.

At times a small stick about the size of a lead pencil is thrust into the proximal end of the tuna after it is peeled. It is then squeezed between the fingers to express as much of the juice as possible. This shortens the drying period three or four days, but much valuable material is, of course, lost, and the product prepared in this way is of inferior quality.

Cartons in which the dry tunas are packed, contain about an arroba (25 lbs.) or 600 dry tunas, for which the producer realizes from \$1.50 to \$2.50, depending upon the character of the crop.

Usually dry tunas are prepared from the white and yellow mansa forms such as amarilla, naranjada, fafayuca, palo al-tena, blanca, teca, etc. The wild forms such as cardona, pachona, agua-mielilla, etc., are too small and contain relatively more spicules, both of which characters are objectionable. Again, the red species dry almost black, and are, consequently, not nearly as attractive in the finished product as the lighter colored varieties.

### Methods of Analysis

The methods of analysis which were used in this work are for the most part those of the Association of Official Agricultural Chemists.\* In some cases the nature of the work seemed to demand a modification of these methods, and the

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\* U. S. Dept. of Agriculture, Bureau of Chemistry, Bulletins 65 and 66.

scheme as used in the laboratory for the determination of each constituent is briefly outlined below.

(1)—*Average Weight.*

Weigh 8 or 10 average sized fruits and divide the total weight by the number taken.

(2)—*Per cent. Rind.*

Remove the rind from the fruit by cutting off each end just through to the pulp, then cutting once lengthwise through the rind to the pulp, and peeling back the rind. A distinct division usually exists between pulp and rind rendering their separation easy. Calculate percentage from average weight of rind and fruits taken.

(3)—*Per cent. Seed.*

Squeeze, by hand, the pulp obtained in (2) through a piece of stout thin muslin. By this means practically all but the seed is forced through the meshes of the cloth. After washing with water dry the seed on water bath and weigh. Calculate percentage from average weight of seed and fruits taken.

(4)—*Per cent. Refuse.*

The per cent. of total refuse represents the sum of average weight of seed and rind divided by the average weight of fruits taken.

(5)—*Per cent. Edible Portion.*

Take the difference between the total refuse and 100 for edible portion.

(6)—*Per cent. Total Solids.*

Place 20 grams of the fresh pulp obtained in (3) in a flat-bottomed dish, which contains from 4 to 5 grams of freshly ignited asbestos. Dry in water jacketed vacuum oven at 70° C. to constant weight, and calculate the total solids.

(7)—*Insoluble Solids.*

Use Kremla's method as modified in Bul. 66, p. 13, Bureau of Chemistry.

(8)—*Specific Gravity of the Juice.*

Filter some of the pulp obtained in (3) through a piece of

thin cloth, and determine specific gravity by means of a Westphal balance. Determine total solids of the juice from its specific gravity by Bul. 65, table IV, p. 32.

(9)—*Total Nitrogen.*

Determine the nitrogen in 10 grams of fruit by Kjeldahl method. Results obtained are used for calculation of amids below. Total proteids are a sum of the albuminoids and amids.

(10)—*Albuminoids.*

Determine in 10 grams of the fruit by method of Stutzer as given in Bul. 46, Rev. Ed. p. 24. Multiply nitrogen by 6.25 for albuminoids.

(11)—*Amids.*

Subtract the nitrogen of albuminoids from the total nitrogen, and multiply the remainder by 4.25 for amids.

(12)—*Acids.*

Take from 10 to 30 grams of the pulp, or better 100 c. c. (10 grams) of filtrate from insoluble solids (7) and titrate with N-10 potassium hydroxid. When the juice is highly colored, its own coloring matter will serve as an indicator of the end reaction, otherwise use phenolphthalein or cochineal, (calculate to per cent  $H_2SO_4$ .)

(13)—*Polarization (Direct).*

Weigh 26.048 grams of the fruit, transfer to 100 c. c. flask, add 50 c. c. water, and from 3 to 5 c. c. subacetate of lead, and about 10 c. c. alumina cream to clarify. Make up to volume, filter and polarize.

(14)—*Polarization (Invert).*

In a flask graduated to 50 and 55 c. c. place 50 c. c. of the clear solution prepared in (13). Fill to the 55 c. c. mark with concentrated hydrochloric acid. Place flask in the water bath and heat until the thermometer marks  $68^\circ C.$ , requiring 15 minutes in the heating. Remove. Cool to room temperature, polarize and note temperature. Calculate percentage sucrose

by Clerget's formula,  $S = \frac{(a-b) 100}{144 - \frac{T}{F}}$

(15)—*Reducing Sugars.*

Take 25 c. c. of the solution prepared for polarization under (13) and add sufficient sodium sulphate to precipitate excess of subacetate of lead, filter, take an aliquot part (5 c. c.) of this filtrate containing not over .2 grams of reducing sugars, and add to a beaker containing 25 c. c. each of Soxhlet's copper, and alkaline tartrate solutions, and make volume to about 100 c. c. with water. Heat the contents of the beaker over wire gauze with flame so regulated that boiling begins in 4 minutes. Continue boiling for exactly 2 minutes, keeping the beaker covered with a watch glass. Without diluting, filter the cuprous oxide at once on a weighed asbestos felt in a Gooch crucible using suction. Wash thoroughly with distilled water at 60° C., then with 10 c. c. alcohol and finally with 10 c. c. ether.

Dry for 30 minutes in water oven at 100 c. c., cool in desiccator and weigh as  $\text{Cu}_2\text{O}$ . Calculate sugars as dextrose from Allihn's table. Make correction for spontaneous precipitation of Cuprous oxide.

(The asbestos used is specially prepared by digesting with 1 to 3 hydrochloric acid for 2 or 3 days. Wash free of acid and digest for a similar period with a soda solution, after which treat for a few hours with hot alkaline copper tartrate solution of the strength employed in sugar determinations. The asbestos is then washed free from alkali, finally digested with nitric acid for several hours, after washing free from acid, it is shaken up with water for use.)\*

Reducing sugars were calculated to dextrose in this work because an excess of dextrose over levulose appeared to be present in the tunas. Since we know the reducing powers of dextrose in terms of other reducing sugars, these values can be converted into any form of reducing sugars desired by means of their dextrose ratios as given by C. A. Browne, Jr., in the J. A. C. S. XXVIII No. 4.

(16)—*Sucrose by Reduction.*

Invert the same amount of solution (15) as was used for reducing sugars, using hydrochloric acid in the same proportion for inversion as under (14), and invert in a similar manner. Neutralize with sodium hydroxide and determine total

\* Munson and Walker. J. A. C. S. XXVIII No. 6, p. 666.

sugars as dextrose. Subtract from this the reducing sugars obtained under (15) and multiply the difference by .95 for sucrose by reduction.

(17)—*Ash in Soluble Solids.*

Treat 50 c. c. of the solution obtained under (6) as outlined under Determination of Ash, on page 13, Bul. No. 66, U. S. Dept. Agric., Bureau of Chemistry.

(18)—*Alkalinity of Ash.*

Add in known amount an excess of N-2 hydrochloric acid to the dish of ash from (17). Add 1 c. c. cochineal solution and titrate with N-10 Potassium hydroxid. Calculate to  $K_2CO_3$ . One c. c. N/10 KOH equals .00691 grams  $K_2CO_3$ .

(19)—*Alcohol Precipitate.*

(*Vegetable mucilage, pectin, and salts of organic acids*). Determine by method given in Bul. No. 66, Bureau of Chemistry, p. 21.

### Composition of Tunas

#### Total Solids

The solid matter in the fruit is about an average of that found in other fruits as may be seen from Table No. 5. Like all other fruits the amount of solids differs for the different varieties, amounting to from 5.33 in No. 6, San Antonio (*O. lindheimeri*), to 11.60 in No. 8057 (tuna amarilla). No. 5, Agricultural College, had a higher solid content than the latter, but is not comparable with the other fruits because it is an *Echinocereus* and the seed were included with the other solids, they being edible in this group of the plants.

The amount of total solids in any fruit is not necessarily an indication of their value, though usually high solids indicate high soluble solids and a high sugar content, and the nutritive value of any fruit is dependent on the amount of these. Since the solids of the tuna are practically all soluble in water, and a large percentage of the soluble material is sugar, the total solids of this fruit is usually an index of its nutritive value, but this is not always the case. No. 5, San Antonio, for example, has 7.13 per cent. solids and only 1.41 per cent. of these

solids is sugar. But with most tunas practically all the total solids of the pulp exclusive of seed are soluble, and a high percentage of the soluble portion is sugar. There are few fruits that will make as good a showing as the tunas in this respect. In many of the small seeded fruits like figs and strawberries the seed are included in the total solids, while in other like apples and pears there is a large amount of marc\*, and both the seed and marc being insoluble make a large difference between total and soluble solids. In the total solids determinations of the tuna the seed were not included and the marc is exceedingly small in quantity, as may be seen by taking the difference between the total and soluble solids.

The total solids of the juice is calculated from its specific gravity. This determination should be about the same as the soluble solids and total sugars. Where the sugars are more than the soluble solids or the total solids of the juice, there is probably some error in soluble solids determination. The total solids of the juice is quite often higher than the soluble solids, due no doubt to the fact that some pulp was in the juice when its specific gravity was taken.

Almost without exception the fruits from Mexico contain more solids and sugar than those varieties native to the United States.

#### Protien

The proteids are a group of bodies found in greater or less quantity in all foods, but the amount found in any fruit is usually quite small.

Bananas, figs, currants, and apricots have been found to contain over one per cent. proteids, but as a rule fruits have less than one-half per cent. This is true of the tunas, which average about the same as is found in the pear, the apple, or the peach.

Protein alone can furnish material for building flesh or muscle in the animal body. A man of moderate work will require as much as one pound of protein for every six pounds of carbohydrates eaten. If the cactus fruit should have .5

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\* Material insoluble in water.



per cent. protein and 10 per cent. sugar, and all, or equal amounts of both, be digested, those Mexicans who make this fruit their exclusive diet would get 20 pounds of carbohydrates for each pound of protein obtained. It is plain to see, therefore, that some other nitrogenous food should be eaten with tunas as with all other fruits to balance a ration.

The proteids are not compounds of definite chemical composition, but they are made up of a group of bodies each differing somewhat from the others in their composition. One element common to all the proteids is nitrogen, but the amount of this element varies in each compound.

The food chemist usually makes no attempt to separate completely the various proteids occurring in any food, but he often separates them into two smaller groups of *Albuminoids* and *Amido bodies*, or *Amids*.

#### Albuminoids

The albuminoids are those nitrogenous compounds which more nearly resemble the white of an egg in their composition and function in the animal body. They all contain very close to 16 per cent. nitrogen in the molecule, hence in the method for their estimation in the laboratory the amount present in a food is determined by multiplying the percentage of nitrogen which they contain by the factor 6.25, which has been used in all of our calculations of albuminoids in the tables.

The albuminoids are the most valuable of all the protein compounds because they are the only ones that can serve as building material in the animal body. In an average of all the Mexican samples there were .377 per cent. total proteids. Of this amount only .107 was albuminoids. Thus it may be seen that roughly, not one-third of the total proteids of the tuna is in the form of albuminoids, which, of course, means that less than one-third of the total proteids of this fruit is muscle and flesh-forming.

#### Amids

Amids, the other group of compounds into which the chemist divides the total proteids, are a group of nitrogenous compounds that are present in plants, especially their fruits.

They constitute one of the first products formed by the plant in its synthesis of nitrogen with the other elements in forming the more complex albuminoids, or they are cleavage products formed in the decomposition of the latter, hence they have fewer atoms in the molecule and a greater proportion of nitrogen. In our calculations we have assumed that all the amids of the tunas contain 23.53 per cent. nitrogen, and have consequently calculated the amount present by multiplying the percentage of nitrogen which they were found to contain by 4.25.

The amids are not so valuable a food as the albuminoids. They are probably incapable of serving as building material, but may, like the carbohydrates, serve as fuel and are also thought in some way to protect and prevent the consumption of proteids of the body tissue.

Because of the comparatively large quantity of amids in the total proteids the amount of the latter in the tunas would not be equal in value to the same amount of proteids in meat or many other nitrogenous foods.

In our analyses we have determined the water soluble proteids, which no doubt include all of the amids and a part of the albuminoids. This determination was made to ascertain the probable available proteids and partly to serve as a check on the total proteids.

#### Acidity

A study of the tables of analyses of the whole fruit as well as rind and pulp shows the amount of acid to be exceedingly variable in the different varieties of this fruit. In fact, it was found to be variable for different samples of the same variety, depending, no doubt, upon the degree of ripeness of the fruit.

The amount of acid in the rind varies from .13 per cent. in tuna amarilla (8057) to .96 per cent. in tuna chavena (8100). In the pulp of the Mexican samples there was .02 per cent. in tuna agua-mielilla (8119), and .32 per cent. in tuna durasnilla blanca (8143).

The acid was found to be much more in those samples collected in the United States with the exception of the tuna tapona from California, which had only .07 per cent. The

average acid in the pulp of the samples from San Antonio was 1.2 per cent., while No. 6, from that place, has 2.15 per cent. acid. The ratio of acid to sugar in these six samples was 1 to 7.5, which is enough to give the fruits a decidedly tart taste. While the acid is not too high the sugar is not in sufficient quantity to make the fruits so desirable as the Mexican varieties. One trouble with the Mexican samples seems to be that the ratio between acids and sugars is too great to give them the requisite tartness. For example, the average acids and sugars of these samples show a ratio of 1 to 119, while even such fruits as the banana and fig have a ratio of about 1 to 70 between their acids and sugars, and in some fruits the ratio is as low as 1 to 5 or 6.

It is of interest to note the large amount of acid, 3.48 per cent., in *O. imbricata*, which is the only sample of a *Clyindropuntia* included in our list. This fruit contains no sugars and is not edible, but was analyzed because of its high acid content. Few, if any, common edible fruit contain so large an amount of acid. The acids in ripe apples rarely exceed 1 per cent., lemons and limes contain only about 5 per cent. citric acid (calculated as sulphuric).

The amount of acid found in the tunas has been expressed in the tables as sulphuric acid, ( $H_2SO_4$ ), because this is the customary manner of expressing such results. This furnishes a ready means of comparing the relative amounts of acid found in different fruits. We have separated and determined the acid in several varieties of the tuna and found it to be malic acid. There were no volatile acids in any of the fresh samples tested.

#### Sugars

*Polarizations.* With very few exceptions all fruits and unadulterated fruit products are levorotatory towards polarized light, but an examination of tables No. I, II, and IV will reveal the fact that while some varieties of the tuna were levorotatory, most of those examined were dextrorotatory both before and after inversion. This unusual phenomenon has caused us to devote some little time to a study of the polariza-

tions of the tuna and some of the preserves prepared from them. While in all probability their dextrorotation is due to a large excess of dextrose over levulose, we are not prepared to say definitely that such is the case; in fact, we can not say definitely whether the dextrorotation may be due to dextrose or to some other sugar or substance. "Miel" and "melcocha", two products from the tuna that are prepared by evaporating the juice to the consistency of honey, have small white wart-like crystals somewhat larger than a pin head scattered throughout the mass. These crystals are not so soluble as the rest of the material, and a 50 per cent. solution of alcohol dissolves almost everything else, leaving them in a fairly pure condition.

When these crystals are separated they are decidedly dextrorotatory, exhibit the phenomenon of birotation, give the cobaltous nitrate test, and have other properties in common with dextrose; but a careful separation and study of the different sugars of the fruit has not been completed, and we can not yet say just what they are, or in what proportion they are to be found in the fruits, but we have made double polarizations for each sample, and from these data calculated the sucrose by Clerget's formula, as well as by reduction.

The probabilities are that the sucrose obtained by polarization, which is as a rule more than that obtained by copper reduction, is too high, the apparent large amount of sucrose having doubtless resulted from the birotary action of the fruits in the reading before inversion, which property was destroyed on boiling for inversion.

For a long time we were not aware that the fruits contained sugars that were birotary, and this no doubt explains why we had considerable trouble in getting uniform results from the same samples, and even sometimes from the same solutions. For this reason we are not sure of the accuracy of many of the polarizations reported in this bulletin. It is clearly shown, however, that most of the fruits and their products are slightly dextrorotatory. The sucrose and total reducing sugars have both been carefully determined in each sample by copper reduction, and it is believed that these results are fairly accurate.

The difficulties resulting from birotation in the polarizations

of the fruits and products may be seen in the results here given of two samples of miel, and one of melcocha. These were all read from a one-fourth normal solution, which had been treated with lead acetate and alum-cream in the usual manner.

|                                                  | Miel No. 1. | Miel No. 2. | Melcocha. |
|--------------------------------------------------|-------------|-------------|-----------|
| Polarization immediately after solution.....     | +5.6        | +3.9        | +3.6      |
| Polarization six or more hours after solution... | +3.1        | +1.8        | +2.5      |

For normal solutions multiply these figures by 4.

Each of these solutions was read from time to time and its dextrorotation was found to slowly decrease until it reached the last figures given in the table in about six hours, after which it underwent no further change.

By referring to table No. 1 it will be seen that the rind was dextrorotatory before inversion in every sample, and after inversion in all but No. 8143 (*durasnilla blanca*). Another interesting fact concerning the sugars of the rinds of the fruit is that while they had less reducing sugars, they were often more dextrorotatory than the pulp of the same fruit, but there was a greater change in the readings before and after inversion, and consequently more sucrose in the rind, for the Mexican varieties at least. The average percentage of sucrose in the pulp of these is .17 per cent., while for the rind the average was .59 per cent. Of all the fruits analyzed that were grown in the United States there was an average of .70 per cent. sucrose, while in the Mexican samples there was an average of only .21 per cent.

In the analysis of a fruit product it is now customary for the food chemist to report those samples which are dextrorotatory as adulterated with glucose. If the tuna or its sugars should ever be added to the products from other fruits sufficiently to cause them to be dextrorotatory, it would be necessary to make further tests for glucose adulteration. Since in some localities an enormous yield of the fruits can be produced per acre on land not well suited to other crops, and in a country where labor is cheap, their production for the adulteration of other fruit products is at least an economic possibility.

The large amount of coloring matter, salts of organic acids, mucilage, etc., often make it very difficult to get a clear solu-

tion for reading in the polariscope. The products from the fruits, and a few of the fruits themselves had to be treated with both lead acetate and alum-cream and at times filtered through animal charcoal when very highly colored.

An attempt was made to remove the coloring matter with sodium hydrosulphite ( $\text{Na}_2\text{H}_2\text{S}_2\text{O}_5$ ), but by the use of this reagent alone we found that we could not clarify sufficiently. If, however, we added about  $\frac{1}{4}$  gram of it to a part of the filtrate from the lead acetate and sodium sulphate, we would effectually complete the decoloration. The sodium hydrosulphite reduces the polarizations, however, more than animal charcoal, especially if the solution was allowed to stand a while before reading. This seemed to indicate that the large quantity of sulphur dioxide liberated had some action on the sugars. One sample of miel, after standing until it had lost its property of birotation, polarized at +3.1, but after treating with hydrosulphite and standing for three hours more its polarization was only +2.3.

*Sugars by reduction:* Under total sugars by reduction in the tables of analyses all the sugars present in the fruits are reported as dextrose. As stated elsewhere, this was done because we believe that nearly all of the sugar in most of the fruits occurs in this form, rather than as levulose, or any other reducing sugar. Sucrose was not often found present, and the probabilities are that often when traces of it are reported it was in fruits that were not thoroughly ripe.

It is customary to report the total sugars in fruits as invert sugar regardless of the kind of sugars present, and in Table No. V, which is a compilation of the analyses of several fruits, from a number of sources, the total sugars are all reported as invert, but as the copper reducing power is about the same for invert sugar, dextrose, and levulose, the percentages would not differ materially when reported in any of these forms. For further discussion of this point see methods of analysis, page 38.

The percentage of sugar varied a great deal for the different varieties, and, as was to be expected, it varied at times for the same variety, depending, no doubt, upon the season and degree of ripeness.

The only *Cylindropuntia* analyzed had no sugar; it is doubt-

ful if the fruit of any of this group contain any appreciable quantity, since none are edible.

The samples from San Antonio, Texas, contained less sugars than those from any other locality; No. 6 had no sugar; No. 3 had only .85 per cent. The sample with the largest amount of sugars is 8485, (tuna amarilla). This fruit had 11.70 per cent. The sample of this same variety collected in 1905 had 11.07 per cent.

The Mexican samples averaged 9.53 per cent. sugar. The San Antonio samples averaged 2.94 per cent., but No. 2, the highest in sugar from the latter place, had 7.18 per cent. For the six American varieties in which the whole fruit was analyzed, the percentage of sugars was 5.61; this it will be seen is more than the average sugar in the pulp of the San Antonio samples as given above, but there are included some that should really be classed with the Mexican samples since they are cultivated forms of Mexican origin much superior to any received from San Antonio. The average in all of the whole fruits of Mexican samples was 7.66 per cent.

While there was some sugar in the rind of all the samples analyzed, only those that seemed of some probable value were examined. The rind of tuna cardona, (8099), and tuna durasnila (blanca and colorada, 8143 and 8150), contained more sugars than did the rinds of any of the other varieties.

The products of this fruit which were analyzed contained from 51.06 per cent. sugar in the tunas pasadas to 64.16 per cent. in one sample of melcocha.

#### Alcohol Precipitate

This name is applied to a group of bodies that are precipitated upon the addition of 95 per cent. alcohol to the juices of the fruits. Plant mucilage, pectin bodies, and salts of organic acids are among these bodies.

Pectin is that substance that causes juices to jell when evaporated to the proper consistency, and our object in making these determinations was to estimate if possible the relative quantity of this material present.

The alcohol precipitation in the tuna pulp is considerably less than is obtained from other fruits that are commonly used

in the preparation of jellies; the average amount found in all the pulps was .29 per cent. while .67 per cent. is found in the cherry, which, perhaps, contains about an average quantity for fruits of this character.

The alcohol precipitate of the rind is three or four times that of the pulp. In one sample there was 2.33 per cent. while for all the rinds examined the average alcohol precipitate was 1.29 per cent.

Since the rind contains more alcohol precipitate than an average fruit, one might be led to believe that its juice could be made to jell very rapidly, but such is not the case. We have been unable to make jelly from either the pulp or rind of any of the varieties tested.

A further study of the alcohol precipitate will show that evidently only a very small amount of it, if any, is in the form of pectin. No doubt quite a bit of this precipitate is plant mucilage; especially is this true of the rind, which is morphologically the modified stem, and this portion of the plant contains so much mucilage that its juice is very slimy. K. Yoshimura\* found this mucilage to be composed principally of galactan. E. F. Ladd\*\* states that the mucilage is due to "pectosic products", but if such is the case it seems that cooking should cause fruits containing it to jell.

The amount of ash in the alcohol precipitate has been determined by us in the pulp of eight samples, and in the rind of three, and the results are given below:

#### Ash in Alcohol ppt.

| Rind.         |               | Pulp.               |               |
|---------------|---------------|---------------------|---------------|
| Sample No.    | Per cent. ash | Sample No.          | Per cent. ash |
| 8099 .....    | 40.20         | 4 San Antonio ..... | 27.92         |
| 8135 .....    | 29.15         | 8099 .....          | 25.10         |
| 8150 .....    | 51.25         | 8135 .....          | 26.04         |
|               |               | 8134 .....          | 29.16         |
|               |               | 8136 .....          | 17.24         |
|               |               | 8141 .....          | 24.00         |
|               |               | 8142 .....          | 20.34         |
|               |               | 8146 .....          | 26.92         |
| Average ..... | 40.20         | Average .....       | 24.59         |

\* Note on the Chemical Composition of Some Mucilages, by K. Yoshimura. Bul. Col. of Agr., Tokyo, Japan. Vol. 2, No. 4, pp. 207, 208.

\*\* Sixth Annual Rep. New York Experiment Station.



Thus it may be seen that about 40 per cent. of the alcohol precipitate from the juice of the rind, and about one-fourth of that from the pulp, is ash.

The amount and character of this precipitate shows that something else is precipitated in abundance by the alcohol, together with the mucilage and pectin bodies, if there be any at all of the latter. Neither of these bodies (pectin and mucilage) would contain so much ash, besides the precipitate formed would be flocculent in character, whereas in the precipitate from both the rind and pulp there was a decided turbidity, which would indicate the precipitation of salts of organic acids, with possibly some dextrose.

The ashes from the alcohol precipitate are the basic constituents of organic salts of calcium, magnesium and potassium, and the large amount of these ashes shows that the precipitate is largely composed of organic salts.

#### Starch

The iodine test on the ripe fruits failed to reveal the presence of starch in any of them.

#### Ash

The examination of the ash of the cactus fruit has consisted principally in a determination of the amount in the soluble solids. Since nearly all the solids are soluble, the soluble ash is almost equivalent to the total ash. This is seen in the few analyses of total ash recorded in the tables. The average soluble ash in the pulp is .29 per cent., which is about the same amount found in apples, pears, or watermelons, and less than is found in the citrus fruits.

As with other plants, the seed of this fruit is also quite low in ash, it being in No. 8022, for example, only .28 per cent. of the whole fruit, which is about the same as is found in the fresh pulp.

The amount of ash in the different parts of the fruit in numbers 8037 and 8038 is tabulated below:

|                                           | No. 8037 | No. 8038 |
|-------------------------------------------|----------|----------|
| Rind, per cent.....                       | 1.06     | 1.40     |
| Whole fruit (pulp and rind), per cent.... | .74      | .42      |
| Pulp and seed, per cent.....              | .21      | .31      |

It will be seen from the above that the ash in pulp and seed taken together is about the same as the average of the pulp alone of all the fruits (.29 per cent.).

The character of the ash is decidedly alkaline. Dr. Bigelow\* has found this to be true with the ash of fruits generally. The alkalinity of the ash of the pulp calculated to potassium carbonate amounts to 55 per cent. of the total ash. The alkalinity of the ash of the rind calculated in a similar manner amounts to 41.18 per cent., while for the whole fruit 48 per cent. of the ash is potassium carbonate.

Very little can be said in regard to the plant food removed from the soil by the tunas until we can determine what the yield per acre will be. The amount of total ash removed by the fruits is very small compared to the amount removed by the stems, which in one instance amounted to 33 per cent. of the dried plant.\* Most of this ash was found to be composed of lime and potash salts which are in abundance in most semi-arid soils, and if so large an amount of these salts is necessary for securing the best results with this plant, it will probably never suffer for the lack of them anywhere in the Southwest.

It will be interesting to determine whether specimens of this plant, grown for years in Florida and other parts of the world where there is not such an abundance of soluble salts in the soil, continue to have their high ash content. Such is not the case with many other plants, and we doubt if the cacti grown in regions of abundance of rainfall will be found to contain so much ash.

The ash is also characterized by a very low content of phosphoric acid. An analysis of the ash from 28 samples of cactus averaged only 1.39 per cent. ( $\text{PO}_4$ ), while other plants seldom have less than 4 per cent.

\* Bul. No. 66, Bureau of Chemistry.

\* See Bulletin No. 60 of the New Mexico Station.

**The Species and Varieties  
of  
Tunas Studied**



No. 8057 and 8485.

## TUNA AMARILLA, (Yellow Tuna)

### *Opuntia* sp.

A tall, open branching species 10 to 15 feet high, with a black, scaly trunk 8 to 12 inches in diameter; joints narrowly oval, about 7 to 8 inches by 15 inches, but, of course, variable, bright light green; spicules yellow, not prominent on joints; spines numerous, white, turning to a chalky, mottled, dirty-gray, flattened-triangular and a little twisted, about 1 inch long, 3 to 15 in number; flowers orange with considerable red in outer segments, giving it a red appearance when closed, style and filaments containing a tinge of red and stigma light green; fruit large, oval to obovate,  $2\frac{1}{2} \times 3\frac{1}{2}$  inches, usually somewhat rough, tuberculate, with greenish rind becoming reddish-yellow on complete maturity, and yellow pulp; formidably protected by large bunches of yellow spicules  $\frac{1}{4}$  inch long.

Tuna amarilla is a cultivated fruit highly prized by the Mexican people. In addition to the above description, it may be stated that very often the fruit presents a tinge of deep dull red before being cut open, but usually the yellow predominates and is decidedly apparent when the fruit is cut open. The red coloration is due to streaks of red which run through the rind coincident with the vascular bundles.

Among all the samples of tunas included in our list there are none superior in size and flavor to this one. Of the earlier samples, 4.8 would weigh one pound, but of the last it required only 2.75 to weigh a pound. No. 8485 being the larger of the two samples, had, as was to be expected, less waste material than No. 8057, the smaller one. Especially was this the case when the rind was included in the refuse. There seems to be little or no difference between the two samples other than the size; and a comparison of the analysis of the edible portion of the two will show them to be very similar in composition although No. 8485 was considerably more mature than No. 8057. The large amount of total solids, soluble solids, and total sugars, together with the high specific gravity of the juice, indicate that this has no superior among the samples included in this study so far as its chemical composition goes. There are few of our highly prized American fruits that will make a better showing in this respect, as may be seen from Table No. V.

Both samples were found to contain over 11 per cent. total sugars calculated to dextrose. The results showed the presence of very little, if any, sucrose. It was one of the few samples that was levorotatory after inversion. In fact, the 1906 sample was levorotatory to the same degree both before and after inversion.

The rind of this variety is not palatable in the fresh state, and its analysis given in Table No. I shows that it contains comparatively little sugars (4.09 per cent.). Its total solids are high. The refuse material is not so very large compared with some of the other varieties, even when the rind is rejected. The composition of the whole fruit (rind + pulp) is given in Table No. III. Since the rind has less nutrients than the pulp, the whole fruit will, of course, have less than the pulp alone.

While the rind of this variety is not eaten fresh, it is one of the varieties used in the preparation of tunas pasadas (dry tunas), which are always dried with the rind left on, and subsequently eaten in this way. For this reason we have made separate analyses of the rind and pulp. While the fresh rind has only 4 per cent. sugar, this is greatly increased in the dried rind on account of the large amount of water lost in drying, and the tunas pasadas make a very suitable product for use in cooking in a manner somewhat similar to our dried fruits. A large part of the sugar from the pulp collects on the surface of the rind when dried, and this no doubt helps to make it palatable. The fruits of this variety when dried have over 50 per cent. sugar in the whole fruits.

8057. Collected at San Luis Potosi, Mexico, 12 August, 1905.

8485. Collected at Aguas Calientes, Mexico, 10 September, 1906.

No. 8142.

### TUNA NARANJADA, (Orange)

*Opuntia* sp.

This and tuna amarilla are really very closely related, but the differences, although slight from a taxonomic point of

view, are very constant. The plants, so far as we can see, are very much alike in every way, the main difference occurring in the color of the fruit, the pulp of this one being, as the Mexican name indicates, orange instead of yellow. The fruit in both amarilla and naranjada are very likely to have its pyriform character accentuated, when the lower portion is flabby and does not contain pulp at all. Very often this basal portion has a tendency to simulate some of the characters of the joint. Externally this variety is darker colored than amarilla. Associated with the difference in color of the fruit is often to be found a similar difference in color of other parts of the plant. While size, shape, and color of joints are the same in the two forms, the spicules are somewhat darker in naranjada and the same holds true of the flowers.

This is very fine flavored, somewhat above the average in size, and has a thin rind. The rind is only about  $1/8$  to  $3/16$  inch thick, and constitutes only 32.43 per cent. of the fruit. This is one of the fruits from which it was found difficult to separate the seed completely from its pulp by our method of forcing the fruit through muslin, and as a result the total solids are somewhat higher and the percentage of seed a trifle lower than is shown by the analysis. This fruit contains less seed than do the majority of the other species. In a number of these undeveloped, sterile seed occur, which suggests a possible gradual disappearance of the seed through cultivation and selection.

There is 62.57 per cent. of edible portion in this fruit, which is more than was found in any of the tunas analyzed. While, for reasons stated above, the solids reported in the tables may be slightly low, tuna cardona and tuna amarilla are the only fruits analyzed that had more solids. Cardona had 13.7 per cent. solids, amarilla 13.56, and naranjada 12.92 per cent. The polarization readings on the fruit was +2.1 both before and after inversion, and the total reducing sugars were 9.12 per cent.

Collected at Zacatecas, Mexico, 20 September, 1905.

No. 8140.

## TUNA CAMUESA, (Pippin, Apple)

*Opuntia larreyi* Weber. Cont. U. S. Nat. Herb. 3:423, 1906.

A tall, open branching plant 8 to 12 or 15 feet high, with a black, bare, scaly trunk 8 to 12 inches in diameter; joints obovate to ovate, very large, in proportion of 8x14 inches in last year's growth, bright dark green, areoles obovate for the most part; spicules yellow and commonly formidable even on the joints; spines usually infrequent and often absent entirely, but sometimes one to three in number, but never very prominent, white, with translucent, bone-like tips; fruit large, obovate, often  $2\frac{3}{4} \times 3\frac{1}{2}$  inches, dull red, with comparatively thin rind which is greenish-red or streaked and mottled; pulp red, and easily separable from the seed.

This is one of the finest of the cultivated Mexican varieties, and belongs in the *Opuntia ficus-indica* group. When the rind is removed leaving the pulp intact, the latter has a distinct orange cast. When broken open, it is mottled yellow and red, but becomes deeper red with full maturity. It is one of the most palatable of these fruits, and has comparatively few seed, which, of course, is a decided advantage. Oftentimes one-half or two-thirds of the seed will be found aborted. This we have found to be the case in specimens collected at Los Campos, Aguas Calientes, San Luis Potosi, and Zacatecas.

The fruit averaged 163.84 grams each and were the largest of all the samples except those of tapona from Riverside, California, which weighed 210.6 grams, and the 1906 sample of amarilla which weighed 164 grams, or practically the same weight of this fruit. These have much fewer seed than any of the other fruits, and a comparatively thin rind, which with the seed make a total waste of 43.94 per cent. There are 11.9 per cent. of total solids in the edible pulp, nearly all of which is soluble. Acid is present in very small amount, .031 per cent. The juice is levorotatory to the same degree both before and after inversion, indicating an excess of levulose and no sucrose. The total sugars as dextrose amount to 11.05 per cent.

Collected at Zacatecas, Mexico, 19 September, 1905.







"TUNA CAMUESA"

(Illustration  $\frac{3}{8}$  actual size. SEE PAGE 56)

No. 8039.

## TUNA MANSA MORADA, (Mulberry Colored)

*Opuntia* sp.

A large, open branching tree with hugh joints, in age often 11x19 inches and this year's growth 10x14 inches, obovate, bright dark green; spicules brown, but not prominent upon the joints; spines white, flattened, turning to a mottled, dirty-gray, slightly twisted, with opescent points,  $\frac{1}{4}$  to  $\frac{3}{4}$  inch long, 2 to 3 in number, but increasing to 12 or more at times upon old trunks, erect, spreading, with one or two lower ones recurved; fruit oblong-obovate, usually slightly tuberculate, with circular areoles  $\frac{1}{2}$  inch or less in diameter, bearing formidable brown glochids 1.8 inch long, dull red exteriorly; rind reddish-yellow, turning to completely red at maturity; pulp blood-red, slightly mottled until dead ripe and clinging tightly to the seed from which it is difficult to separate it.

This is one of the popular tunas of Mexico and one which has not been met with in the open country. For some reason it is not extensively grown, there being only a few plants in scattering orchards. It is finely flavored and of good size.

This sample was analyzed August 14, 1905, seven days after its collection. It was in good condition. The average weight of the fruit was 66.5 grams, which is somewhat below the average weight for the Mexican varieties, but much heavier than those of the United States. It was one of the first analyzed after this work was undertaken. At that time the significance of the method of preparing the fresh fruit to be eaten was not fully appreciated. For this reason in this sample, as well as in 8037 and 8038, we only have the analysis of the pulp with that portion of the rind which would naturally remain after peeling the fruits as one would an apple. Nearly all of the best varieties included in this bulletin have had the pulp analyzed separately and it is unfortunate that this fruit was not treated in a similar manner. However, it may be seen from an examination of the composition of the whole fruit with epidermis and seed rejected that it compares favorably with the best of those varieties that are reported in a similar manner in Table No. IV.

Since, as a rule, the pulp alone contains a greater percentage of nutrients than the whole fruit, it is likely that the pulp of

this sample would have been about equal in value to tuna cardona. The waste in this sample amounts to 21.83 per cent. If all the rind had been rejected the waste would have been 46.75 per cent., about the same as cardona. The total solids amount to 11.62 per cent., all but 1.22 per cent. of which is soluble in water. The total solids of the juice calculated from its specific gravity amounts to 9.38 per cent. The acidity of the juice is only .047 per cent., or less than the average of the pulp alone of all the fruits, which is .08 per cent. The average acidity for the whole fruits of all the Mexican varieties is .247 per cent. The sugars by reduction are somewhat less than one would expect from the soluble solids and high specific gravity. It is likely that the results for sugar, 7.82 per cent., are slightly low, although they would naturally be somewhat low because of the presence of the rind.

By peeling a quantity of these fruits and exposing them to the sun until air dry, the total dry matter was found to be 17.43 per cent. If the 4.65 per cent. seed be taken from this, we have 12.78 per cent. edible dry matter left, which, considering the small amount of water left in the air dry sample, checks the total solids determination (11.62 per cent.) fairly well.

Collected at San Luis Potosi, Mexico, 7 August, 1905, sample consisting of 19 fruits from 4 plants.

No. 8050.

### TUNA TECA, TUNA BLANCA TECA, TUNA MEXICANA, TUNA AMERICANA

*Opuntia* sp.

This variety is known by all of these appellations in the vicinity of San Luis Potosi, and it may be the same as subsequent forms which we discuss under still other names. The distinguishing characteristic of the fruit is that it is greenish-white when mature. On the whole, it resembles very much the "Mission pear" of Southwestern United States. It is very variable in spine characters, but this particular specimen





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has spines 2 to 5 in number on last year's joints, but increasing very much with age. The spicules are light reddish-brown, seldom prominent upon the joints. The fruit is ovate-obovate, about  $1\frac{3}{4}$  to  $2\frac{1}{4}$  inches, yellowish-green throughout or possibly greenish-white would apply better to the pulp. The seed are apparently few and cling closely to the pulp.

This is a highly prized variety with fine flavor, good appearance, good size, and reasonably thin rind. It is one of the varieties that one will always find upon the market places in season.

An examination of the table will show the similarity in composition between this and the following numbers. In size No. 8050 is about a mean of that of the other two samples (8146 and 8547). The waste amounts to 48.1 per cent., which is about the same as that of the other two. They are all characterized by high total and soluble solids, but a slightly low sugar content. The total solids for the three amounts to about 11 per cent., and the sugar from 8 to 9 per cent. It is easy to tell by tasting them that they are not as sweet as tuna amarilla for example, but they have a very excellent flavor, which with their large size and thin rind makes them desirable fruits.

Collected at San Luis Potosi, Mexico, 9 August, 1905.

Nos. 8146 and 8547.

### TUNA BLANCA, (White)

*Opuntia* sp.

This may be the same as No. 8050. The people here do not know the name tuna teca at all. This particular specimen is spiny like our "Mission pear", but some plants are to be found here which are almost destitute of spines or spicules, but this character is not constant at all, even in the same plant. This tuna sells on the markets here for about the same price as camuesa, indeed, all of the large cultivated forms sell for about the same money.

Both of these samples have been referred to in the discussion of tuna teca (No. 8050), which they very much resemble in

both appearance and composition. This is one of the large cultivated fruits, and has a good percentage of edible pulp, the seed of which are often undeveloped, and not so abundant as they are in many varieties. No. 8146 weighed 76.3 grams, and No. 8547 weighed 123.75 grams. The total solids in the first was 10.81 per cent., and 12.35 per cent. in the second. Both fruits were slightly dextrorotatory, and contained a fraction of a per cent. of sucrose. There were 8.29 per cent. total sugars in the first, and 8.99 per cent. in the last sample.

No. 8146. Collected at Zacatecas, Mexico, 21 September, 1905.

No. 8547. Collected at Zacatecas, Mexico.

No. 8037.

### TUNA RANCHERA, (Ranch)

*Opuntia* sp.

A tall, open branching tree 8 to 10 or 12 feet high, with black, scaly trunk 8 inches or often a foot in diameter; joints ovate-obovate, with often a tendency to be pointed at both ends, although the prevailing form is obovate, in proportion of 9x15 inches, which is a common size, rather light green; spicules yellow, infrequent upon the joints; spines short,  $\frac{1}{2}$  to  $\frac{3}{4}$  inches long, erect, spreading, 2 to 3 or 4 on young joints, but increasing to 10 on 3-year old ones at this age turning to a dirty-gray and apparently drop off, divergent or a few recurved upon the edges of the joints; fruit large,  $1\frac{1}{4}$ x $2\frac{1}{2}$  inches, oval to obovate, with large circular areoles 1.8 inch in diameter, bearing yellow, formidable spicules and hair-like fugacious spines, very dull, deep red, with some green exteriorly even when mature, rind greenish or mottled yellow and red; pulp, when rind is removed, presenting light orange-yellow appearance but mottled when cut open, the red color being situated mainly around the seed.

This is a valuable cultivated variety which has a wide range in spine characters, some forms being nearly spineless. The fruit compares favorably with the other large mansa forms, such as amarilla, in flavor, but the tunas are somewhat smaller. Although described as mottled, there is usually not enough coloring matter in either pulp or rind for slices of them to stain paper when they are laid upon it. The species should be classed with *Opuntia ficus-indica*.

Tuna ranchera is one of the few good fruits of which, unfortunately, we have no separate analysis of the pulp, both this and the rind having been included in one sample. The analysis given in Table No. IV will show this to be one of the best fruits so far as total solids and sugar content is concerned. It is about the same size (57.3 grams) as cardona, and the composition of the edible portion when rind is included is also about equal to that of this fruit when it is prepared and analyzed in a similar manner. It was more dextrorotatory than any sample included in our list, being +3.7 both before and after inversion. There was only .07 per cent. acid in this sample, which is quite low for any of the tunas where the rind is included with the pulp. A determination of the ash content of the different parts of the fruit shows 1.06 per cent. ash in the rind, .21 per cent. in the pulp, and .74 per cent. in the whole fruit.

The fact that there was 85.08 per cent. edible portion simply shows that the fruit was peeled by removing only a very small part of the rind.

Collected at San Luis Potosi, Mexico, 7 August, 1905.

No. 8065a.

### TUNA TAPONA,\* (Cork or Plug)\*\*

*Opuntia robusta* Wendl. Cat. Herrenh. 1835.

When well developed, this is one of the most attractive of the native Mexican tunas. It is almost globular, more or less tuberculate, and blood-red when ripe. It thrives nicely at Riverside, California. Like many other species, the pulp becomes edible while the rind, which is red when mature, is still perfectly green. In the early part of the season the fruit upon the market is, therefore, largely green, while later it is blood-red. Maturing, as it does, very early, a great deal of the fruit is destroyed by birds which begin eating it as soon as the pulp begins to turn red.

\* For description of the plant see Bul. 60: 69, 1896, N. Mex. Station.

\*\* Referring to its action on the bowels.

Although large and attractive in appearance, this is not considered a very good species of tuna, mainly on account of the deleterious effects the Mexicans believe it has on digestion. It is said that it has a tendency to produce constipation, and that death sometimes results therefrom. However, it is extensively eaten.

Collected at Ypina, Mexico, 18 August, 1905.

No. 8065b.

### TUNA TAPONA

*Opuntia robusta* Wendl. (?)

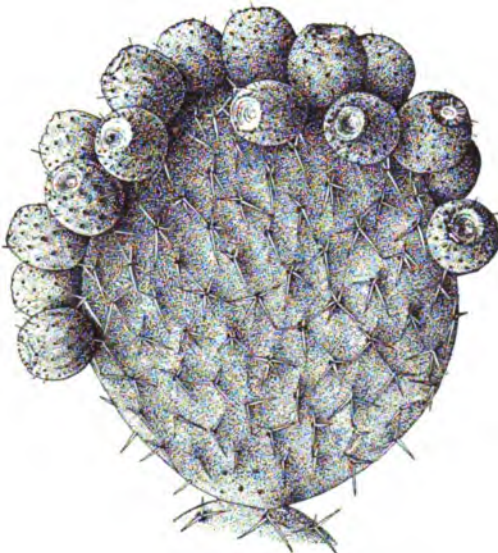
This and 8065a are closely related, but there are constant differences which prevent our placing them together. This is a larger plant throughout, and this is the main difference, although there are other minor points of distinction which when once seen are easily recognized. This one has joints which are larger, more nearly circular, and not so thick and plump as the common tapona of the San Luis Potosi region. The fruits in this variety are larger, but otherwise the same, and the same distinctions are true regarding the flowers. Both forms grow fairly well at Riverside, California, but we have never seen it growing native like the others. There are nearly spineless forms of both varieties.

Because of its very large size, and the fact that it was one of the very few United States grown fruits analyzed that appeared to be of much value, it is to be regretted that we failed to make a more complete analysis of it. We have, however, made the complete analysis of No. 8065a, and probably the greatest difference between these two samples is in the size. The waste is less in this one. The solids, determined from the specific gravity of the juice, is just about the same, but there is a big difference in the acidity. No. 8065a contained .21 per cent. acid, while this one had only .07 per cent. This is doubtless accounted for, in part at least, by the fact that the California sample was more mature.

These fruits are the largest we have analyzed, being three times the size of tuna tapona, from the State of San Luis Potosi, Mexico.

Forwarded from the A. S. White Park, Riverside, California, August, 1905.

Nos. 8051 and 8099.

**TUNA CARDONA***Opuntia streptacantha* Lem.\* Cact. Gen et Sp. Nov. p. 62.  
1839.

**TUNA CARDONA.**  
(About  $\frac{1}{4}$  natural size)

This is without doubt the most highly prized of all the Mexican tunas. It is smaller than the cultivated varieties, but is very palatable, and the Mexicans say it may be eaten in quantity without any deleterious effects. The whole fruit is purplish-red throughout, with a pulp of much deeper color than the remainder; and the epidermis showing considerable

scaly wax covering when fully ripe. In shape it is oval to subglobose, about  $1\frac{1}{2}$  to  $1\frac{3}{8}$  inches in longest diameter. The fruit resembles very closely tuna cochineria and tuna artona. It is rather doubtful whether it is specifically distinct from the latter, but it is certainly distinct from the former.

Many of the cultivated species produce larger tunas and ones which are just as palatable, if not more so, but cardona has several advantages over others. It is abundant, cheap, a native species, very palatable, and with no deleterious qualities like tapona and some of the others are said to have. Fre-

\* See Bul. 60: 65. 1906. New Mexico Station.

quently it is planted, but not usually in the protected orchards, for it is sufficiently spiny to need no protection. Cuttings are commonly planted in the open country, in order to extend the native thickets. It is especially abundant upon the markets of San Luis Potosi, Augas Calientes, and Zacatecas, where one may often find piles containing 30 or 40 bushels brought in from the surrounding hills and deserts.

In view of the fact that this is the most abundant, widely distributed, and most universally used of all the Mexican species, we have devoted considerable time to a study of the composition of both the pulp and rind, and an analysis of both of these parts will be found in tables No. I and II respectively, while in table No. IV the analysis of the fruit without the seed and epidermis is also given. In order to determine the effect of storage on the composition, we have also made analyses of samples at three different periods of storage, both in 1905 and 1906; the first analysis given in the table being that of the fresh fruit immediately after its receipt in the laboratory, the second, that of fruits selected from the same lot as the first after standing ten days, and the third being the analysis of fruits that had been stored, as packed for shipment, for 20 days.

Tuna cardona is at least equal in nutritive value to any of the tunas, although considerably below the average in size, and not quite as highly flavored as amarilla, naranjada, or camuesa.

Sample No. 8051 was smaller and had more rind and seed than the other two samples. It has only 34.8 per cent. edible pulp, 11.47 per cent. solids, and 9.76 per cent. sugar as dextrose, this being less than was found in the other samples, doubtless due to the fact that 18 days elapsed between the collecting of this number and the second sample, thus giving the latter time to more fully mature.

No. 8099 was, as stated above, analyzed at three different periods for both the years 1905 and 1906, and the results are reported under Nos. 8099, 8099a, and 8099b in Table No. II. The rind was also analyzed and the results reported under Table No. I. We were not able to notice any marked differ-

ence in the composition of the pulp or rind of the fruit when stored beyond what might be expected in different fruits of the same variety. One very noticeable change, on standing, however, was the loss in weight of the rind and a still greater decrease in the weight of the pulp. For the purpose of showing this change, the weights and percentages of the fruit and its rind and pulp for the different periods of storage during the seasons of 1905 and 1906 is given below. From this table it may be seen that on standing for 20 days the percentage of rind increased from 42.66 to 61.70.

**Table VI. Showing Effect of Storage on Weight and Relative Amounts of Rind and Pulp**

| Year . . . . .            | WT. IN GRAMS |       | PER CENT. RIND |       | PER CENT PULP. |       |
|---------------------------|--------------|-------|----------------|-------|----------------|-------|
|                           | 1905         | 1906  | 1905           | 1906  | 1905           | 1906  |
| Fresh . . . . .           | 50           | 60.5  | 42.66          | 48.92 | 54.02          | 47.69 |
| 10 days storage . . . . . | 49           | 53.15 | 51.53          | 50.0  | 45.08          | 46.75 |
| 20 days storage . . . . . | 47           | —     | 61.70          | —     | 35.35          | —     |

The figures here given would seem to indicate that the water in the fruit passes from the pulp into the rind, but if such is the case this movement takes place without any material change in the composition of either pulp or rind that we were able to detect in the analysis.

The amount of acid in this fruit was unusually low both in the pulp and rind. In the pulp of all the samples it averaged .05 per cent., and in the rind .21 per cent., which is less than half of the average for all the other Mexican samples.

The juice of every sample of 8099 tested was dextrorotatory before and after inversion. Sometimes both polariscope and reduction methods showed a very small amount of sucrose in the pulp, and still more in the rind which at times seem to have as much as 1.5 per cent. The rind of none of the fruits contained as much total sugar as did this one (7.2 per cent.), which is almost as much sugar as the pulp of average temperate zone fruits. The total sugars as dextrose were de-

terminated in seven different samples of cardona and the average for these determinations was 10.22 per cent.

No. 8051 collected at Alonzo, Mexico, 11 August, 1905.

No. 8099 collected at Aguas Calientes, Mexico, 29 August, 1905.

No. 8436 collected at Aguas Calientes, Mexico, 4 September, 1906.

No. 8038.

## TUNA PALAMITA

*Opuntia* sp.

A tall, open branching cultivated nopal 10 or 12 feet high, with a black, scaly trunk 6 to 10 inches in diameter; joints obovate, in proportion of  $6\frac{1}{2}$  to 12 inches, which is a common size, slightly bluish-green, becoming cracked and scaly with age; areoles obovate, about 1-16x1-8 inches, but increasing slightly with age; wool tawny; spicules light brown; spines flattened, triangular, twisted, some recurved, others erect-divergent,  $\frac{1}{2}$  to 1 inch long, white with opalescent darker points, 2 to 4 in number, but increasing to 6 or 7 at age of three years, and increasing slightly even beyond this, but becoming abraded from old trunks; fruit about  $1\frac{1}{2}$ x $2\frac{1}{4}$  inches, ovate-obovate, mottled and dull red when fully matured; rind finally turning to a streaked brownish-red and pulp mottled.

This fruit is formidably protected with light brown spicules 1-16 or more inches long from circular areoles about  $\frac{1}{2}$  inch apart. It is well flavored, but not promising, on account of the many spicules. We have never seen this species excepting in cultivation. The fruit is sweet and palatable, and, were it not for its small size (33.1 grams), and large quantity of spicules, it would be very desirable. No separate analysis was made of the pulp, unfortunately; but judging from the analysis of the whole fruit, there are few tunas whose edible portion shows a superior composition. There are 12.43 per cent. total solids in the whole fruit and 8.87 per cent. sugar.

Collected at San Luis Potosi, Mexico, 7 August, 1905.



No. 8119.

## TUNA AGUA-MIELILLA, (Honey Water)

*Opuntia* sp.

A tall, open branching native tree 12 to 25 feet high, with a bare, scaly, black trunk 10 to 14 inches in diameter; joints ovate-obovate, about 8x12 inches, which is a common size, deep dark green, soon turning to a gray-black; spicules reddish-brown, but never prominent upon the joints; spines white, becoming mottled, flattened, twisted, erect-divergent, 4 to 6, with lower and usually two laterals recurved; flowers (only two or three seen) deep orange, with red in midribs of outer segments, always causing them to look red when closed; style bright red, filaments lighter red, stigma yellow with streaks of red through outside of the 6 or 8 divisions; fruit small; subglobose to obovate, about 1½ inches in longest diameter, deep dark red with darker pulp, which is easily separable from seed, formidably protected with small, circular areoles containing bunches of reddish-brown glochids surrounded by the blackened ends of the wool.

As the popular name suggests, this is a very sweet and palatable tuna, but is too small to favorably compare with the cultivated forms, and the better wild species, such as cardona. These fruits averaged 30.84 grams in weight which is less than half the average size of the Mexican tunas that we studied. Another serious objection is the large percentage of waste in rejecting the thick rind which amounts to 57.72 per cent. The solids and soluble solids (10.98 and 10.78 per cent. respectively) are high. The acid (.024 per cent.) is less than was found in any of the fruits. The percentage of proteids (.89 per cent.) is not high for fruits generally, but is more than was found in the other samples of prickly pears.

The total sugars amount to 8.84 per cent. No sucrose was found by reduction methods, and only very small trace by polarization, the readings being to the right before and after inversion. Because of the large quantity of rind an analysis was made to determine the nutritive value of this portion. The results are recorded in the table of analyses of the rinds, and from these it may be seen to have 7.27 per cent. solids in the juice of which only 2.76 per cent. is sugar.

Collected at Dublan, Mexico, 12 September, 1905.

No. 8102.

**TUNA LEONERA***Opuntia* sp.

A tall, very open branching tree 15 feet high, largely used for hedges and line plantings here. Joints deep dark green, about the same color as cardona, obovate, about 5 to 7 inches by 8 to 12 inches spicules reddish-brown, not formidable upon the joints, really seldom visible except in the spineless areoles at the base; spines 4 to 7 on last year's joints, but increasing very much on old wood, white, turning to a mottled condition, and finally dirty-black, flattened, twisted, one to two inches or more long and erect, with upper shorter, spreading and lower usually recurved; flowers (only two seen) orange with greenish filaments, reddish style and light green stigma; fruit almost globular, deep dull red, with pulp darker and rind of medium thickness, formidably protected with reddish-brown spicules from small, circular areoles, about  $\frac{1}{4}$  inch apart; seed easily separable from pulp.

This tuna is small, but has a very good flavor, and is consequently well thought of in parts of Mexico. It is eaten fresh and also employed in the manufacture of miel, melcocha, and queso, for which it is said to be admirably adapted. The composition of the edible portion as seen from the analysis in the table shows it to be one of the three best fruits, but as with agua-mielilla its small size and thick rind prevents it from being classed as it would otherwise be. The fruits weighed only 30 grams, and 68.66 per cent. of this was rind, which with the 3.33 per cent. seed left only 28.01 per cent. of edible pulp. The solids of the edible portion amounted to 13.21 per cent., 10.78 per cent. being sugar. By reduction none of this was found to be sucrose, and polarization only showed .38 per cent. Both polarizations were to the right.

Collected at Encarnacion, Mexico, 1 September, 1905.

Nos. 8141 and 8546.

**TUNA PACHONA***Opuntia* sp.

A tall, rather compactly branched tree 10 to 15 feet high, with a black, scaly trunk 6 to 10 inches in diameter; joints ovate-obovate, about 7x13 inches, deep dark green, with waxy white covering often

prominent, resembling cardona in color very much, but on the whole a little lighter; areoles 1 to 1½ inches apart, ovate to circular; spicules bright reddish-brown, but often yellowish at their bases, not often formidable on joints except at the bases of the younger ones; spines white, flattened or triangular, with translucent, bone-like tips, usually slightly twisted, somewhat but never tightly recurved, 2 to 5 in number; flowers not seen; fruit red, becoming decidedly purplish when fully matured, formidably protected with large bunches of reddish-brown glochids from large circular areoles.

This is a bright, clear red tuna which becomes deep red to purple when completely ripe. It is one of the most attractive of the leonera-opalilla-agua-mielilla group, and is largely used in the manufacture of queso and other pulp products. It sold on the day of collection upon the markets of Zacatecas at the rate of seven or eight for one cent, while amarilla, camuesa, etc., were selling at the rate of two for one cent.

Tuna pachona closely resembles tuna cardona in composition. The average weight of the individual fruits of the cardona sample collected in 1905 was 49 grams, while the pachona for the same year averaged 48.2. The two resemble each other also in having a "mealy" juice, that is, when the juice is expressed there is a considerable amount of very finely divided solids (marc) in suspension.

The pachona sample collected in 1906 (No. 8546) was about the same in size as the one collected in 1905, and the amount of seed and rind as well as the composition of the pulp was about the same in both. The total solids amounted to about 12 per cent., and a calculation of the solids in the juices of the two from their specific gravity shows this to be not far from 12 per cent. for both samples, while the reducing sugar amounted to about 9 per cent.

Strange to say, No. 8141 was dextrorotatory to a fraction of a degree both before and after inversion, and No. 8546 was slightly levorotatory in both cases. The latter was more fully matured than the former.

No. 8141. Collected at Zacatecas, Mexico, 19 September, 1905.

No. 8546. Collected at Zacatecas, Mexico, 19 September, 1906.

Nos. 8100 and 8136.

## TUNA CHAVENA\*

*Opuntia* sp.

When fully ripened this tuna does not differ very much in outward appearance from tuna cardona. It is, however, slightly longer and lighter in color, especially during the ripening period. It differs also in being protected by yellow, instead of reddish-brown spicules, and in maturing about six weeks or two months later. Chaveña and its closely allied varieties are among the latest to mature in the fall, with it its two varieties are almost always associated. Tuna caidilla differs from it in having rather smaller joints and in the one important characteristic of dropping its fruit as soon as mature. The Spanish name "caidilla" is probably derived from "caier", to fall. The fruit is said to remain in good condition upon the ground for a month or six weeks. The other variety is tuna cascarona, differing again from chaveña in having somewhat larger and more uniformly circular joints and possibly slightly larger tunas. These three forms are very closely related and would scarcely be considered distinct species by the most critical taxonomist, but they are quite well recognized by the Mexicans, who will pick them out, especially during the fruiting season, with considerable regularity. As stated above, tuna chaveña, together with its varieties, mature late in the season, and are the forms best adapted to winter use. In the vicinity of Aguas Calientes large quantities of these are stored and placed upon the market continuously through April. They are packed, as stated elsewhere in this publication, in well aerated situations in alternate layers with straw or hay. Specimens which we have examined as late as the middle of April were in a good state of preservation.

Although somewhat under ripe No. 8100 had evidently attained its full growth and sugar content. These tunas averaged 11.23 grams heavier than the fruits of No. 8136 which were gathered in the same locality two weeks later. This va-

\* See Bul. 60: 73. 1906. New Mexico Station.

riety is about an average size, but it is characterized by a very large amount of rind in proportion to pulp. The percentage of seed is somewhat less than was found in some of the other varieties, but the amount of rind is very large, and it is not edible. When this was rejected the total refuse was about 75 per cent. Because of this large amount of waste, the rind of 8100 was analyzed and found to contain 4.97 per cent. sugar. The acids were rather high in the rind, (.96 per cent.), which was probably due to the fruit not being thoroughly ripe. Both samples were somewhat similar in composition. The solids, sugars, and proteids of 8136 were somewhat more than was found in the greener sample, by far the greatest difference being in the proteids. The polarizations were to the right in both samples both before and after inversion. No sucrose was found by reduction in either, but the polarizations seem to show .24 per cent. in 8136. This is about an average of the Mexican fruits so far as sugar and proteids are concerned. The test with iodine failed to show any starch in 8100.

Neither sample changed its color when evaporated to dryness on the water bath as do many of these fruits.

No. 8100 collected at Aguas Calientes, Mexico, 29 August, 1905. This specimen was collected from the very earliest tunas to mature and is really considerably under ripe. The natives had not begun to use it at all.

No. 8136 collected at Aguas Calientes, Mexico, 15 September, 1905. This specimen was none too ripe; although the ripest fruits obtainable were selected for the analysis. The natives were just beginning to eat them at the time this sample was collected.

Nos. 8143 and 8545.

### TUNA DURASNILLA BLANCA, (White Peach)\*

*Opuntia leucotricha* DC. Rev. d. la. Fam. d. Cact. 119: 1829.

This is a light yellow fruit when mature, and reaches a size of  $1\frac{7}{8} \times 2\frac{1}{4}$  inches, but is usually smaller than this. It is one

\* See Bul. 60: 75. 1896. New Mexico Station.

of the very few aromatic tunas of Mexico, although we are informed by Mr. Francis Eschauzier that this is a common characteristic of the tunas which have become naturalized in Southern Spain. Differing from many species, the rind of this assumes more of the consistency and flavor of the pulp when mature and is consequently eaten, the practice usually being to cut off the peel rather roughly, leaving about one-half of it attached to the pulp when the operation is completed. In this way about one-half of the peel is consumed with the pulp. To many foreign tastes this is a pleasant fruit on account of its slight pungency, the other species being often complained of as insipid. This, however, is no more true of the tunas than of many subtropical fruits. See further discussion under next number.

No. 8143. Collected at Gutierrez, Mexico, 20 September, 1905.

No. 8545. Collected at Zacatecas, Mexico, 19 September, 1906.

No. 8150.

### TUNA DURASNILLA COLORADA, (Red Peach)

*Opuntia leucotricha* DC.\* Rev. d. la. Fam. d. Cact. 119: 1829.

We are unable to discover any constant differences, except that of color, between this and No. 8143. Both forms are aromatic and both are eaten with a portion of the peel attached to the pulp. Both have formidable spicules and hair-like, fugacious spines of the same color. It is the peel and epidermis that is most highly colored in this variety. The pulp becomes red very tardily and then it is only mottled, the red being confined to that part of the pulp adjacent to the seed.

It resembles No. 8143 as much in its chemical composition as in its botanical and physical characteristics, and for this reason the samples are discussed together. Since both rind and pulp of these two fruits are usually eaten, a complete analysis has been made in each fruit of both these portions separately, as well as of the whole fruit (minus seed and

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\* See Bul. 60: Pl. IV. 1896. New Mexico Station.

peeling), and the analyses as given in Tables I, II, and IV will show a remarkable similarity in the composition of the different parts of the two. The average weight of each sample was 42.9 grams for 8143 and 40.6 grams for 8150, both being considerably below the average weight and size of the larger tunas.

Like tuna chaveña (8136 and 8100) they have a very thick rind, (about  $\frac{3}{8}$  inch), but inasmuch as it is palatable this cannot be offered as so much of an objection to them, yet while the rind of both fruits is superior to the rind of other fruits examined, with the exception of tuna cardona (8099), it is not equal in value to the pulp either in composition or flavor, and the same fruit with a thinner rind would, of course, be preferred. As mentioned before, it is doubtless the presence of a large amount of plant mucilage and salts of organic acids that render the rinds unpalatable, and in No. 8150 these were found to be less than one-half of the amount usually found in this portion of the fruit, as shown by the amount of alcohol precipitate, (see Table I). The amount of ash was also considerably less in both samples than is usually found in the rind. About the only marked difference in the two fruits is in the amount of acid, there being more than twice the amount of acid in the white variety (8143), than was found in the red (8150).

While, as before stated, these fruits are quite similar in composition, there was found somewhat more pulp in the durasnilla blanca than in durasnilla colorada, but the total and soluble solids, the proteids, specific gravity and sugars are practically the same in both. As in the rind, the acid in the pulp of the former is more than twice that of the other. Both of these fruits are smaller, contain less sugar, and other nutrients than some of the other samples, but the palatability of their rinds makes them desirable fruits.

Collected near Zacatecas, Mexico, 22 September, 1905.

No. 8134.

## TUNA VINATERA

*Opuntia* sp.

A tall, open branching plant often 12 to 15 feet high, with a gray, scaly trunk 8 to 12 inches in diameter; joints prominently pubescent, tuberculate, narrowly obovate, 3 to 4 inches by 10 to 14 inches in last year's growth, light yellowish-green; spicules lemon yellow, very formidable near base of joint, but not so prominent above, often  $\frac{1}{4}$  inch long; spines white, erect, spreading, flattened and twisted with prominent, translucent, bone-like tips, as much as  $1\frac{1}{4}$  inches long, 2 to 4 or 5 in number, very formidable and stout, increasing rapidly with age and enlarging the areoles upon the old trunks to often  $\frac{1}{2}$  inch in diameter, and containing as high as 30 strong spines; flowers deep orange with red in midribs of outer segments, which are irregularly separated and often cleft; filaments and style red, with pulp deeper colored than rind and clinging closely to seed, pubescent, tuberculate, deeply pitted at top, in this respect much like fruits of some of the species of *Nopalca*, formidably protected by yellow glochids from triangular areoles 3-16 to 5-16 inch apart.

Although very pleasantly flavored, this species has many disadvantageous characteristics. The fruit is small, the pulp clings closely to the seed and the spicules are very numerous. It is quite extensively eaten in the field, but seldom found upon the markets, and is not very highly prized. It is the smallest of any of the fruits analyzed with the exception of one or two samples of little or no nutritive value. They only average 24 grams per fruit, but the rind was not so thick as in some of the other fruits of good quality like leonera and agua-mielilla. The edible pulp constituted 50.17 per cent. of the fruit, and this had 12.14 per cent. solids, nearly all soluble, 10.22 per cent. being sugar. No sucrose was found by reduction, and only a trace by polarization, the polarization being +2.3 before and +2.1 after inversion.

Collected at Aguas Calientes, Mexico, 16 September, 1905.

No. 8135.

## TUNA JOCONOXTLE, (Ho-con-ox-tle)

*Opuntia* sp.

A medium-sized, rather compactly branched native plant 6 to 10 feet high, with a gray, scaly trunk 6 to 8 inches in diameter; joints large, obovate, in proportion of 8x11 inches, which is a common size,



minutely papillate-hairy, soft and silky to the touch, dull green, becoming yellow and scurfy and finally gray scaly; areoles circular, about one inch apart; spicules yellow and rather prominent even on joints; spines white, turning to a dirty-gray, flattened, slightly twisted, weak, erect-divergent, very unequal in length, longest about one inch, the lower often somewhat recurved; flowers yellow; fruit subglobose to slightly obovate, about  $1\frac{1}{4}$  inches in diameter, dull red with pulp deep red and rind lighter, papillate-hairy, with circular to obovate areoles about  $\frac{1}{4}$  inch apart.

There are several very distinct varieties which pass under the above common name. We are not certain that they all belong even to the same botanical species. The most obvious characteristics are found in fruit coloration, but there are other taxonomic distinctions also. This variety has fruit red or red-dish-purple throughout. Another variety has green fruit with red pulp; another has fruit green throughout when fully mature. All of the varieties agree, however, in one respect, namely, they are not palatable in the fresh state. They need to be cooked before being eaten.

The rind in this species is comparatively thick and the pulp not palatable. It is, therefore, not eaten until cooked. Its main value is in the manufacture of preserves, for which there is a large use.

A rather complete analysis has been made of both rind and pulp, and the composition of these parts, as well as that of the whole fruit, is reported in the different tables. The average weight of this variety is 41.17 grams, which is below the average size. 68.46 per cent. of this is rind, only 26.95 per cent. being pulp free from seed. It contains less nutrients than any of the edible samples received from Mexico, with the possible exception of tuna cuija.

A comparison of the analysis of the whole fruit of these two samples in Table No. IV shows the total and soluble solids in joconoxtle to be 7.02 and 5.34 per cent. respectively, while for tuna cuija they are 8.45 and 7.50 per cent. respectively. But cuija has only 4.18 per cent. sugar, while joconoxtle has 4.76 per cent. in the whole fruit. The pulp of the latter has 7.74 per cent. sugar, but we have no data for sugar in the pulp of the former.

These are the only tunas from Mexico with less than 10 per

cent. total solids and with so low a percentage of sugar. In this respect they more nearly resemble those forms native to the United States.

Collected at Aguas Calientes, Mexico, 15 September, 1905

Nos. 1 to 6. (Wm. Sinclair).

### PRICKLY PEAR, NOPAL

*Opuntia lindheimeri* Engelm.\* Boston Jour. Nat. Hist.  
6:207. 1850.

Very little use is made of this fruit, and our analyses show that it has comparatively little merit as a food. Occasionally a family is found which makes a sort of preserve of the peeled fruits; others dry them, while others eat them in the fresh state, but usually they simply drop off the plants and are eaten by hogs and cattle. There is a strong opinion prevalent among both Americans and Mexicans in portions of southern Texas that the fruit produces injurious effects. However, this may be, it is certain that it is very often eaten with no injurious consequences whatever, although not very palatable.

A total of six samples of this species have been analyzed, all collected by Mr. William Sinclair, at San Antonio, Texas, as follows:

No. 1. 1 August, 1905. This is the only one of those fruits from San Antonio, Texas, which had the pulp and rind analyzed together as one sample, and for that reason it is not readily comparable with the other numbers in its solids and sugar contents, but it is probably one of the best fruits from that locality.

The tables show about twice as much sugar in No. 2, which was collected six or seven weeks later in the season, but the solid matter is about the same for both, and the difference in sugar can be largely accounted for by the fact that the rind is included in sample No. 1.

The tables show a high percentage of edible portion because

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\* See Bul. 60: 32. 1906. New Mexico Station, and Bul. 91: 9-11. 1906. B. A. I., U. S. Dept. Agriculture.

only the seed and a very thin epidermis is included in the waste. The fruits were crimson in color, averaged 43.5 grams in weight, and were about 1.5 by 2.5 inches in size. The sample had 3.94 per cent. total reducing sugars, and .88 per cent. sucrose. The total solids determination was lost, but the solids in the juice calculated from the specific gravity is 7.74 per cent.

No. 2. 19 September, 1905. This sample of *Opuntia lindheimeri* was collected about seven weeks later than the previous one, and was the largest and best sample from San Antonio. The fruits were 1.75 to 3 inches in diameter, and weighed on an average 71.63 grams. The rind of this sample was very thick (about  $\frac{1}{4}$  inch in its thinnest part), and was a very deep purple. Like all the samples from Texas, there was a large percentage of waste. There were 7.78 per cent. of total solids, and 7.18 per cent. total sugars.

No. 3. 17 November, 1906. The individuals in this sample averaged about  $1 \times 1\frac{1}{2}$  inches in size, and weighed 25 grams. Like all the fruits of this species, it was sour and unpleasant to the taste. In some of the fruits the pulp was gray or yellowish-green in color. The rind was very thick and constituted 67 per cent. of the total. Only the pulp was included in the analysis, and this amounted to 25 per cent. of the fruit. It has only 5.68 per cent. solids. Of these solids 1.18 per cent. was acid, .48 per cent. proteids, and .85 per cent. total sugars. If this fruit were palatable the small amount of edible portion, and the low solids and sugar render it of little value.

No. 4. 4 July, 1906. The pulp only was included in the analysis of this sample. It amounted to 33.29 per cent. of the whole fruit. There were 7.8 per cent. solids, of which 7.27 per cent. were soluble, 5.24 per cent. was sugar, and .88 per cent. acids calculated to  $H_2SO_4$ . It is interesting to note that while this fruit contained only 5.24 per cent. sugar, it was the best sample of this species. It was levorotatory before and after inversion, both polarization and reduction showing a fraction of one per cent. sucrose.

No. 5. 16 October, 1906. This consisted of small, somewhat shriveled, green fruits, and a number of them had begun to decay. They averaged 21 grams in weight. The rind was green

for the rind and pulp. The pulp was separated from the peeling and seed in a press. The edible portion obtained by this process amounted to 78.18 per cent. of the fruit. The total solids were 10.11 per cent. and the sugars 7.51 per cent. This was one of the few tunas that was levorotatory both before and after inversion. By polarization no sucrose was found, and only .14 per cent. was found by reduction; it contained .22 per cent. acid calculated as  $\text{H}_2\text{SO}_4$ .

This is probably the most palatable prickly pear that is at present found growing in New Mexico, and while it is not eaten as a fresh fruit very extensively here, it is used considerably by the Mexicans in the preparation of preserves.

Some of the pulp of this fruit was evaporated to about one-eighth of its original volume to a thin paste without suffering any change in its color. This paste was used for coloring apple jelly and candy, and was found to serve admirably for the former purpose. Because of the danger or prejudice against the use of the coal-tar dyes, it may have some value commercially as a vegetable coloring matter. Candy colored by means of it lacked the brilliancy of that colored with coal-tar dyes, and it is doubtful if it could ever be very generally used for this purpose. The paste prepared in this manner had 51.6 per cent. sugar, only .48 per cent. being sucrose. By removing the sugar and insoluble solids from the material the coloring matter could probably have been concentrated to as rich a color as cochineal paste. We expect to investigate the coloring matter of this fruit more fully the coming season.

As to whether or not the fruits will ever prove of commercial value for the preparation of a coloring matter will, we believe, depend solely upon the yield per acre that can be obtained. This can only be determined by experiment.

Collected from Cactus Garden, New Mexico Agricultural College, 20 August, 1906.

No. 8022.

*Opuntia phacacantha* Engelm.\* Mem. Am. Acad. (Plant. Fend.) 4:52. 1849.

This fruit is rather small and too acid to be of use as an article of human food. It is pyriform, about  $1 \times 1\frac{1}{2}$  inches, rather sparingly beset with small areoles, having formidable yellow glochids  $\frac{1}{8}$  inch or less long. It is light reddish-purple without, and has a rind of the same color, but the pulp, which is quite acid, is greenish-yellow and the seeds comparatively large.

It will be seen that this brief description varies somewhat from that given in Bul. 60. 1906, New Mexico Station. We cannot tell about the character of the fruit of the type of *Opuntia camanchica* for reasons stated in that publication and the description is not explicit. It may be necessary later to admit under this specific name forms with fruits bearing the following colors:

1. Reddish-purple throughout.
2. Reddish-purple on outside and greenish-yellow within.
3. Reddish-purple epidermis and rind and greenish-yellow pulp.

The fruit was prepared for analysis by peeling the skin or epidermis with as little waste of the rind as possible, which was analyzed together with the pulp, freed from seed. There were in this sample 15.84 per cent. seed, this being more than was found in any of the samples analyzed. The peeling was only 12.06 per cent. making a total waste of seed and peeling of 27.9 per cent.

The total and soluble solids were not determined in this sample, but the solids in the juice calculated from its specific gravity were 11.00 per cent.; and the sugars amounted to only 3.35 per cent. making a purity coefficient of the juice of only 30.5 per cent., while with the juices of the best fruits it was as high as 80 to 90 per cent. This low coefficient in the purity of the juice is found in all the fruits with a low sugar

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\* See Bul. 60: 50. 1906. New Mexico Station, for notes on this and *O. camanchica*.

content, when the rind was included in the analysis with the pulp. The other solids doubtless consist of acids, salts of organic acids and mucilage. 1.58 per cent. is acid calculated as  $H_2SO_4$ .

Reduction methods showed 2.6 per cent. of the sugar to be sucrose, but we are inclined to believe that there must be an error in these results since the juice seemed to have very little if any effect on polarized light, and no sucrose was found by polarization.

Collected at El Paso, Texas, 30 July, 1905.

#### Nos. 1 and 4. (New Mexico Garden)

*Opuntia macrocentra*. Englm. & Bigel. Proc. Am. Acad. Arts and Sci. 8:292. 1856.

At the time of collection it was noticed that there were two kinds of mature fruits on the different plants in a plantation of this species upon the College campus. They resembled each other in their outward appearance, except that No. 1, collected in 1905, was about twice the size of No. 4, collected in 1906. The pulp of No. 1 was red, while that of No. 4 was green, or yellowish-green. The fruits of sample No. 1 averaged 29.28 grams, while those of No. 4 weighed only 14.5 grams.

No. 1 was prepared for analysis by peeling off the epidermis and forcing the pulp and pericarp through muslin. The amount of edible portion obtained in this manner amounted to 78.46 per cent. The edible portion in No. 4 was obtained by subjecting the fruits to pressure and weighing the juice thus obtained. In this way only 59.68 per cent. was edible. The total solids in No. 1 were not determined, but a calculation from the specific gravity of the juice shows the solids in this sample to be 8.92 per cent. The total solids in No. 4 were 12.08 per cent. and the soluble solids 11.63. Calculated from the specific gravity of the juice the solids present in No. 4 amounted to 12.60 per cent. No. 1 has .85 per cent. acid, and No. 4 .47 per cent., or about half the amount found in No. 1.

Both samples were levorotatory at both readings, and both seemed to have some sucrose, with a larger quantity in No. 4.

No. 1 had 3.87 per cent. total sugars as dextrose and No. 4 had 9.03 per cent. The small fruit with the green pulp which was collected in 1906 was a better fruit than the one collected in the previous year, as may be seen from its composition. It has more solids and sugar, and less acid. Whether this is due to the season, the fact that it was collected ten days later in the month, the difference in the size of the two samples, or varietal difference we cannot say. A difference in the color of the pulp is a common one in the prickly pears. Similar differences to the one noted here are common in *O. engelmannii*, *O. lindheimeri*, *O. phaeacantha* and many others.

No. 8035.

#### TUNA JUELL, (Whae)

*Opuntia imbricata*, (Haw.) DC.\* Prodr. 3: 47. 1828.

*Cereus imbricatus*, Haw. Rev. Pl. Suc. p. 70. 1821.

This is the common cylindropuntia of the highland region of Mexico. The fruit is not eaten by either man or beast, so far as we have been able to determine. As the analyses show, it is very high in acid, and because of this and the presence of so much plant mucilage and absence of sugar it is not at all palatable.

Before the advent of the coal tar dyes into Mexico this fruit had an important place in the arts. The tunas were gathered, chopped up into small pieces, and boiled, the fiber and seed being filtered out and the extract used to dissolve and set cochineal dye. It is still used in this way to a limited extent. Experiments which we have conducted show it to be somewhat efficient for the purpose, especially in the coloring of woollen cloth. Its mordanting property is doubtless due to the large amount of acids and salts of organic acids present.

This is the only analysis of cane cactus (*Cylindropuntia*) included in this bulletin. The fruits of this group of the cacti are not edible, nor was this particular sample. The analysis was made to determine its composition compared to the prickly pears. The fruits average 51.66 grams in weight.

\* See Bul. 60: 97. Pl. VII, fig. 2. 1906. New Mexico Station.

The percentage of seed is 9.68, which is higher than was found in any of the fruits except *O. phaeacantha*, (8022).

The total solids were only 7.57 per cent., 5.54 per cent. being soluble in water. The juice contained an unusually large amount of plant mucilage, which rendered it so slimy that we could not determine the specific gravity at all by means of a Westphal balance, and upon attempting this determination with a gravity balance, the unavoidable bubbles in the slimy juice caused the specific gravity to be only .903, or less than water, which is, of course, too low. The proteids present were about an average of what is usually found in the other tunas. The fruit contains 3.48 per cent. of acid, which was found to be malic acid. The large percentage suggests a possibility of the use of the plant for the preparation of this acid. No trace of sugar was found either by reduction or polarimetric methods.

An analysis of the ash of the soluble solids in this fruit is given below. A comparison of its composition with the composition of the ashes of the stems of the cacti as given in Bulletin No. 60, Table No. 2, New Mexico Experiment Station, shows it to be comparatively low in lime and high in alkali salts, and sulphates.

Composition of the *ash* in the soluble solids.

|                                                                                                     |       |          |
|-----------------------------------------------------------------------------------------------------|-------|----------|
| Silica, iron and alumina, $\text{Si O}_2$ , $\text{Fe}_2\text{O}_3$ , $\text{Al}_2\text{O}_3$ . . . | .64   | per cent |
| Chlorine (Cl) . . . . .                                                                             | 4.09  | " "      |
| Sulphuric acid radicle ( $\text{SO}_4$ ) . . . . .                                                  | 5.12  | " "      |
| Calcium (Ca) . . . . .                                                                              | 7.15  | " "      |
| Magnesium (Mg) . . . . .                                                                            | 6.83  | " "      |
| Sodium (Na) . . . . .                                                                               | trace |          |
| Potassium (K) . . . . .                                                                             | 33.81 | " "      |

Collected at San Luis Potosi, Mexico, 9 August, 1905.

No. 5 (New Mexico Garden).

### MEXICAN STRAWBERRY

*Echinocereus stramineus*, Englm. Syn. Cact. U. S. in Proc. Am. Acad. Arts & Sci. 3: 282. 1856. U. S. & Mex. Bound Sm. 2: 35. 1859.

This is the only fruit included in this study outside of the



genus *Opuntia*. The genus *Echinocereus* includes many species with edible fruits. In fact their fruits are often preferred to the prickly pears, but their scarceness prevents their extensive use as a food. The fruits in the sample were collected somewhat late in the season and were probably not as good as some of the fruits that matured earlier. They will not stand storage as do the prickly pears, for they ferment very quickly after being collected. These are of a salmon color, weigh about 18 grams and average two inches long and one inch in diameter at the largest part. They are formidably covered with long white spines, but these are completely and easily brushed off when the fruit is ripe. It is covered with a greenish rind, which constitutes 30.38 per cent. of the fruit, but this represents the total refuse, since the small black seeds which are almost as small as those of the strawberry are eaten, and for this reason were included with the edible portion. The edible portion, therefore, amounted to 69.17 per cent., which is more than that of any of the prickly pears with their rinds rejected. The total solids of the edible portion amounted to 18.14 per cent. which is also more than that of the prickly pear, and can be explained in part at least because of the presence of the seeds. The fruit differs from the prickly pears in containing nearly three per cent. sucrose. Its polarization readings were +1.3 before and -2.5 after inversion at 28 degrees C. The total sugars were 9.3 per cent. The unusual amount of sucrose (2.8 per cent.) makes them much sweeter than the prickly pears.

The juice has a very pleasant odor and taste, and if the plants were as abundant as the prickly pear they would be preferable as a food, as they are more palatable, and do not like the tuna contain so many seed that cannot be masticated nor readily removed from the pulp. Neither do they have so much plant mucilage as do the tunas.

Collected 17 August, 1906, from garden on campus of New Mexico Agricultural College.

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AGRICULTURAL EXPERIMENT STATION

AGRICULTURAL COLLEGE, N. M.

CODLING MOTH INVESTIGATIONS  
DURING 1903 AND 1904

BY

FABLÁN GARCÍA

SANTA FE, N. M.

NEW MEXICAN PRINTING COMPANY,

1907

# NEW MEXICO AGRICULTURAL EXPERIMENT STATION

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## **Codling Moth Investigations During 1903 and 1904**

### **Introduction**

The codling moth continues to be the most serious insect pest the New Mexico apple grower has to contend with. After the insect once gets into an apple growing district, it is impossible to get rid of it entirely by any one or all of the methods now extant for combating it. The only thing for the orchardists to do is to reduce its number and in that way save a large per cent of fruit that would become wormy if the codling moth were allowed to take its course without being disturbed.

In order to spray, however, at a time when it should do the most good, requires considerable study and calculation, as it involves a knowledge of the life history of the insect and the appearance of the different broods in each particular section as well as a knowledge of the relation of the appearance of the first moths in the spring to the opening of the apple blossoms or development of the young fruit.

### **Life History**

The following remarks give an idea of the life history of the insect: The codling moth passes through four stages during its life time; the egg, the larva, the pupa, and the moth. It is agreed by practically all authorities that it takes the insect about fifty days to go through these stages.

Gillette\* sums up the life history of the summer brood of the codling moth for Colorado in the following terms: "From egg to larva, seven days; from larva to cocoon stage, 19 days; cocoon stage to emergence of moth, 18 days; emerging of moth to middle of egg-laying stage, 5 days; (estimated)—a total of 49 days, or just seven weeks."

### **The Egg**

The eggs of the codling moth are very small scale-like objects, resembling very small drops of milk and about as

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\* Bulletin No. 31 New Series, Division of Entomology, p. 18, U. S. D. A.



large as the head of a pin. Being so small and more or less transparent, they are difficult to distinguish at first sight. The eggs are found on the twigs, leaves, and apples. The duration of the egg stage seems to vary with the temperature and season. Some observers give the duration of the egg from five to twelve days while others give it from four to ten. The average time being about seven days.

### **The Larva**

When the larvæ or young worms hatch they are very small, probably not over 1-16 of an inch in length; semi-transparent in color, and often marked with minute dark spots. The head is dark or often black. Soon after the young worms hatch they enter the apple, increasing in size as they feed toward the core. The length of time that it takes the larva to become full grown varies considerably. Some observers give this period as being from ten to fourteen days, others from sixteen to twenty-four days, while still others as high as thirty-three days. Melandes and Jenne\* observed that during the summer the codling moth larva remains in the apple from seventeen to thirty days, the average being a little over twenty days. According to Gillette's\*\* records the average at Ft. Collins, Colorado, was nineteen days.

### **Insect in the Cocoon**

As soon as the worms get their growth they leave the apple and spin their cocoons any place,—in the crotches of the trees, underneath clods, piles of weeds or other rubbish on the ground, but most of the worms prefer the main trunk of the trees.

The larvæ from the last brood winter over in the cocoons, and come out as moths in the spring. The insects from the summer brood stay in the cocoons but a short time. Most authorities give the summer period from two to three weeks, averaging nineteen days for the insect to pass from the larva stage through the pupa into the moth. The writer has observed

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\* Bulletin No. 77, Washington State.

\*\* Bulletin No. 31, New Series, Division of Entomology, U. S. D. A.

some pupæ almost ready to turn into moths at the end of one week's time after the larvæ had gone underneath the bands.

The following notes were made from codling moth larvæ hatched in breeding cages in 1903 at this Station: June 15th, 1903, found two full grown moths from larvæ captured June 1st; June 24th, found four full grown moths from larvæ put in the cage June 9th.

### **The Moth**

The hibernating worms, which escape the birds and other harsh conditions during the winter, change into pupæ in the spring, and shortly after that the insects emerge as moths. The observations at this Station indicate that in the Mesilla valley only a comparatively small number of moths emerge in the spring from the large number of worms that go into their winter quarters in the fall. This is further shown by the small per cent of wormy apples found among early varieties. In Bulletin No. 41 of this Station it is seen that in 1901 only 12.85 per cent of the total crop produced by the unsprayed Red June tree, an early variety, was wormy. The date of the appearance of the moths in the spring depends to a great extent upon the weather conditions prevailing. Our observations on this point indicate that at this Station the first moths from the wintered-over worms must have emerged about the first of the third week in April.

The fact that the moth closely resembles the bark of the tree in its coloring and being nocturnal in its habits, is, no doubt, why so few fruit-growers become familiar with the adult insect. The moth itself is harmless to the fruit. It has been estimated that a single moth during its laying period will lay from 50 to 100 eggs. This may account for our heavy second maximum of worms.

### **Relation of the Appearance of the Moths to the Blooming Period**

The appearance of the moths in the spring will be governed chiefly by the weather conditions of the season.

It is difficult to give a definite method for the orchardist to

determine the appearance of the first moths in the spring. In a general way, however, it may be said that the earliest moths from the wintered-over worms may emerge about the time the blooms are falling off or a little later. According to observations made at this Station in 1901, the first worm underneath the bands on three Ben Davis trees was found on May 22nd, while these same trees were in full bloom on April 15th. Counting back 19 days for the time the worm was inside of the apple, 7 days for the hatching of the egg, and from 3 to 5 days before the egg was laid would bring the date of the appearance of the moth 29 to 31 days earlier or about April 22nd. In 1902 the Ben Davis trees were in full bloom April 17th. On May 7th the bands on these trees were first examined but no worms were found. These bands were not examined again until June 4th, when a single worm was found. It is quite likely that the first worm left the apple before June 4th. In 1903 the first worms on four banded Ben Davis trees were found on the 23d of May. The date of the blooming of these trees has been lost. In 1904 the trees were in full bloom April 6th, while the first worms were found May 20th. Again, by counting back about thirty days, it would bring the appearance of the first moths, from the wintered-over worms, about April 20th. According to these observations it is probably true that the maximum number of moths from the wintered-over worms appeared at this Station considerably after the petals had fallen, or about the last of April.

To some extent these observations agree with those made by other observers.

On April 24th, 1897, Cockerell\* recorded the first moth hatched out in breeding jars in Mesilla, a town about three miles west of the Station. The same year the Ben Davis trees in the Experiment Station orchard were in full bloom on April 11th.

Slingerland,\*\* in writing in regard to the blossoming time of the apples and the appearance of the codling moth in the

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\* Bulletin No. 25, New Mexico Experiment Station, p. 49.

\*\* Bulletin No. 142, Cornell Experiment Station, p. 37.

spring says, "Moths may begin to emerge about the time the apple trees are in full bloom. But our breeding experiments and what little definite evidence there is on this point, indicate that the majority of moths do not emerge until several days after the petals have fallen. Then allowing a few days for the preparation for oviposition, we should not expect, and, in fact, do not find eggs until a week or more after the petals drop. Another week must elapse before the eggs hatch, so that theoretically, we should find but few worms until after the blossoms have been off for two weeks or more on most varieties: and this agrees with our observations and with definite evidence recorded by Atkins, Gillette, Washburn, and Card."

#### **Band Records**

In order to get more data on the number of broods, the appearance of the maximum, and the over-lapping of the broods, a daily band record was kept on five Gano apple trees during the season of 1903, on three Kentucky Red Streak and two Northern Spy trees in 1904; and a weekly record in 1903 on four Ben Davis trees. These observations have not been carried on long enough to be conclusive and more work needs to be done on the life history of this insect.

The following tables and diagrams show the detailed data for the two seasons:

CODLING MOTH INVESTIGATIONS

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Table I--Weekly Band Record for Season of 1903

| Date         | No.<br>of<br>Worms | No.<br>of<br>Worms | No.<br>of<br>Worms | No.<br>of<br>Worms | Total<br>per<br>Week |
|--------------|--------------------|--------------------|--------------------|--------------------|----------------------|
|              | Ben<br>Davis       | Ben<br>Davis       | Ben<br>Davis       | Ben<br>Davis       |                      |
|              | No. 1              | No. 2              | No. 3              | No. 4              |                      |
| May 25.....  | 0                  | 0                  | 0                  | 0                  | 0                    |
| June 2.....  | 4                  | 1                  | 0                  | 8                  | 8                    |
| " 9.....     | 1                  | 2                  | 1                  | 7                  | 11                   |
| " 16.....    | 1                  | 1                  | 2                  | 2                  | 6                    |
| " 24.....    | 0                  | 5                  | 3                  | 5                  | 13                   |
| " 30.....    | 4                  | 4                  | 0                  | 9                  | 17                   |
| July 7.....  | 8                  | 3                  | 3                  | 6                  | 20                   |
| " 14.....    | 4                  | 8                  | 2                  | 8                  | 22                   |
| " 21.....    | 14                 | 19                 | 16                 | 24                 | 73                   |
| " 28.....    | 26                 | 9                  | 20                 | 56                 | 110                  |
| Aug. 4.....  | 15                 | 8                  | 17                 | 43                 | 83                   |
| " 11.....    | 10                 | 1                  | 1                  | 14                 | 26                   |
| " 18.....    | 7                  | 7                  | 6                  | 14                 | 34                   |
| " 25.....    | 0                  | 0                  | 1                  | 6                  | 7                    |
| Sept. 1..... | 8                  | 2                  | 0                  | 5                  | 15                   |
| " 8.....     | 3                  | 2                  | 8                  | 23                 | 36                   |
| " 16.....    | 11                 | 1                  | 3                  | 20                 | 35                   |
| " 24.....    | 7                  | 6                  | 3                  | 21                 | 37                   |
| Oct. 2.....  | 2                  | 3                  | 3                  | 7                  | 15                   |
| " 11.....    | 0                  | 0                  | 0                  | 0                  | 0                    |

Table II—Daily Band Record for Season of 1903

| Date        | No. of Worms | No. of Worms | No. of Worms | No. of Worms | No. of Worms | Total daily No. for the 5 trees | Temperature |      | Precipitation* |
|-------------|--------------|--------------|--------------|--------------|--------------|---------------------------------|-------------|------|----------------|
|             | Gano         | Gano         | Gano         | Gano         | Gano         |                                 | Max.        | Min. |                |
|             | No. 1        | No. 2        | No. 3        | No. 4        | No. 5        |                                 |             |      |                |
| May 12..... | 0            | 0            | 0            | 0            | 0            | 0                               | 83          | 51   |                |
| " 13.....   | 0            | 0            | 0            | 0            | 0            | 0                               | 85          | 52   |                |
| " 14.....   | 0            | 0            | 0            | 0            | 0            | 0                               | 80          | 53   | Trace          |
| " 15.....   | 0            | 0            | 0            | 0            | 0            | 0                               | 83          | 55   | .07            |
| " 16.....   | 0            | 0            | 0            | 0            | 0            | 0                               | 79          | 50   |                |
| " 17.....   | 0            | 0            | 0            | 0            | 0            | 0                               | 83          | 50   |                |
| " 18.....   | 0            | 0            | 0            | 0            | 0            | 0                               | 73          | 50   |                |
| " 19.....   | 0            | 0            | 0            | 0            | 0            | 0                               | 82          | 35   |                |
| " 20.....   | 0            | 0            | 0            | 0            | 0            | 0                               | 86          | 42   |                |
| " 21.....   | 0            | 0            | 0            | 0            | 0            | 0                               | 79          | 47   |                |
| " 22.....   | 0            | 0            | 0            | 0            | 0            | 0                               | 85          | 41   |                |
| " 23.....   | 0            | 0            | 0            | 0            | 1            | 1                               | 86          | 37   |                |
| " 24.....   | 2            | 1            | 0            | 2            | 0            | 5                               | 88          | 78   |                |
| " 25.....   | 3            | 1            | 2            | 1            | 0            | 7                               | 89          | 44   |                |
| " 26.....   | 3            | 2            | 0            | 1            | 0            | 6                               | 80          | 44   |                |
| " 27.....   | 1            | 0            | 0            | 0            | 1            | 2                               | 88          | 42   |                |
| " 28.....   | 2            | 0            | 0            | 0            | 0            | 2                               | 88          | 46   |                |
| " 29.....   | 5            | 1            | 2            | 0            | 1            | 9                               | 90          | 49   |                |
| " 30.....   | 5            | 0            | 3            | 4            | 0            | 12                              | 88          | 50   |                |
| " 31.....   | 3            | 2            | 8            | 7            | 2            | 22                              | 85          | 63   |                |
| June 1..... | 4            | 0            | 4            | 6            | 1            | 15                              | 85          | 59   | .02            |
| " 2.....    | 0            | 3            | 1            | 9            | 0            | 13                              | 85          | 45   |                |
| " 3.....    | 1            | 0            | 0            | 5            | 0            | 6                               | 89          | 53   | Trace          |
| " 4.....    | 1            | 0            | 3            | 3            | 1            | 8                               | 89          | 60   | Trace          |
| " 5.....    | 0            | 5            | 0            | 1            | 1            | 7                               | 80          | 58   | Trace          |
| " 6.....    | 0            | 1            | 1            | 2            | 2            | 6                               | 81          | 56   | .22            |
| " 7.....    | 1            | 0            | 0            | 4            | 0            | 5                               | 89          | 56   |                |
| " 8.....    | 0            | 1            | 0            | 2            | 1            | 4                               | 91          | 55   |                |
| " 9.....    | 2            | 1            | 2            | 1            | 1            | 7                               | 85          | 61   |                |

Table II—Daily Band Record for Season of 1903—*Continued*

| Date         | No. of<br>Worms | No. of<br>Worms | No. of<br>Worms | No. of<br>Worms | No. of<br>Worms | Total<br>daily<br>No. for<br>the 5<br>trees | Temper-<br>ature |      | Precipi-<br>tation* |
|--------------|-----------------|-----------------|-----------------|-----------------|-----------------|---------------------------------------------|------------------|------|---------------------|
|              | Gano            | Gano            | Gano            | Gano            | Gano            |                                             | Max.             | Min. |                     |
|              | No. 1           | No. 2           | No. 3           | No. 4           | No. 5           |                                             |                  |      |                     |
| June 10..... | 2               | 1               | 4               | 3               | 1               | 11                                          | 83               | 61   | .01                 |
| " 11.....    | 3               | 0               | 1               | 5               | 2               | 11                                          | 60               | 56   | 2.43                |
| " 12.....    | 0               | 1               | 3               | 1               | 0               | 5                                           | 59               | 52   | .78                 |
| " 13.....    | 0               | 2               | 1               | 1               | 0               | 4                                           | 72               | 53   | Trace               |
| " 14.....    | 1               | 2               | 1               | 3               | 4               | 11                                          | 81               | 53   | .14                 |
| " 15.....    | 0               | 1               | 2               | 3               | 0               | 6                                           | 87               | 52   | .....               |
| " 16.....    | 0               | 2               | 2               | 0               | 0               | 4                                           | 91               | 55   | .....               |
| " 17.....    | 0               | 2               | 1               | 3               | 1               | 12                                          | 92               | 68   | .05                 |
| " 18.....    | 2               | 1               | 2               | 3               | 3               | 10                                          | 94               | 58   | .....               |
| " 19.....    | 0               | 0               | 0               | 3               | 1               | 4                                           | 95               | 55   | .....               |
| " 20.....    | 0               | 3               | 6               | 5               | 2               | 16                                          | 95               | 54   | .....               |
| " 21.....    | 3               | 3               | 3               | 3               | 1               | 9                                           | 95               | 47   | .....               |
| " 22.....    | 1               | 2               | 1               | 5               | 0               | 9                                           | 94               | 53   | .....               |
| " 23.....    | 1               | 5               | 6               | 5               | 0               | 17                                          | 94               | 58   | .....               |
| " 24.....    | 1               | 2               | 2               | 3               | 0               | 8                                           | 96               | 47   | .....               |
| " 25.....    | 0               | 4               | 4               | 3               | 0               | 11                                          | 90               | 53   | .....               |
| " 26.....    | 0               | 1               | 4               | 2               | 1               | 8                                           | 98               | 63   | .....               |
| " 27.....    | 1               | 3               | 3               | 1               | 0               | 7                                           | 102              | 58   | .....               |
| " 28.....    | 1               | 7               | 3               | 5               | 0               | 16                                          | 101              | 63   | .....               |
| " 29.....    | 0               | 3               | 5               | 6               | 0               | 14                                          | 103              | 57   | .....               |
| " 30.....    | 0               | 6               | 3               | 4               | 0               | 13                                          | 102              | 54   | .....               |
| July 1.....  | 2               | 2               | 4               | 6               | 0               | 14                                          | 101              | 52   | .....               |
| " 2.....     | 0               | 0               | 4               | 2               | 0               | 6                                           | 98               | 60   | .....               |
| " 3.....     | 0               | 0               | 4               | 4               | 0               | 8                                           | 95               | 64   | .....               |
| " 4.....     | 0               | 3               | 4               | 4               | 1               | 12                                          | 98               | 60   | .....               |
| " 5.....     | 0               | 0               | 2               | 4               | 0               | 6                                           | 94               | 70   | .....               |
| " 6.....     | 0               | 3               | 2               | 13              | 0               | 17                                          | 98               | 67   | .....               |
| " 7.....     | 1               | 1               | 6               | 5               | 2               | 15                                          | 96               | 61   | .....               |
| " 8.....     | 3               | 1               | 1               | 3               | 2               | 15                                          | 97               | 65   | Trace               |

Table II—Daily Band Record for Season of 1903—Continued

| Date        | No. of Worms | No. of Worms | No. of Worms | No. of Worms | No. of Worms | Total daily No. for the 5 trees | Temperature |      | Precipitation* |
|-------------|--------------|--------------|--------------|--------------|--------------|---------------------------------|-------------|------|----------------|
|             | Gano         | Gano         | Gano         | Gano         | Gano         |                                 | Max.        | Min. |                |
|             | No. 1        | No. 2        | No. 3        | No. 4        | No. 5        |                                 |             |      |                |
| July 9..... | 3            | 5            | 2            | 7            | 0            | 17                              | 97          | 63   | Trace          |
| " 10.....   | 0            | 4            | 6            | 9            | 0            | 19                              | 101         | 70   | .....          |
| " 11.....   | 5            | 5            | 9            | 5            | 0            | 24                              | 101         | 71   | .21            |
| " 12.....   | 4            | 9            | 8            | 5            | 0            | 26                              | 92          | 67   | Trace          |
| " 13.....   | 1            | 3            | 8            | 9            | 1            | 22                              | 92          | 63   | .....          |
| " 14.....   | 4            | 1            | 0            | 8            | 3            | 16                              | 92          | 69   | .....          |
| " 15.....   | 2            | 0            | 7            | 3            | 1            | 13                              | 93          | 64   | .....          |
| " 16.....   | 5            | 5            | 5            | 11           | 2            | 28                              | 93          | 68   | .....          |
| " 17.....   | 1            | 10           | 8            | 10           | 2            | 31                              | 97          | 60   | .....          |
| " 18.....   | 2            | 9            | 9            | 3            | 3            | 26                              | 99          | 61   | .....          |
| " 19.....   | 4            | 4            | 7            | 7            | 9            | 31                              | 94          | 67   | .55            |
| " 20.....   | 5            | 6            | 10           | 2            | 3            | 26                              | 94          | 61   | .....          |
| " 21.....   | 0            | 6            | 9            | 18           | 2            | 35                              | 97          | 62   | .....          |
| " 22.....   | 3            | 9            | 22           | 23           | 8            | 65                              | 97          | 66   | .....          |
| " 23.....   | 4            | 6            | 9            | 8            | 7            | 34                              | 99          | 63   | .....          |
| " 24.....   | 11           | 8            | 2            | 3            | 2            | 26                              | 97          | 63   | Trace          |
| " 25.....   | 5            | 8            | 26           | 17           | 13           | 69                              | 93          | 63   | Trace          |
| " 26.....   | 8            | 0            | 8            | 11           | 3            | 30                              | 99          | 66   | Trace          |
| " 27.....   | 1            | 5            | 1            | 9            | 7            | 23                              | 92          | 62   | Trace          |
| " 28.....   | 8            | 8            | 5            | 12           | 4            | 37                              | 99          | 64   | .15            |
| " 29.....   | 4            | 11           | 3            | 5            | 4            | 27                              | 101         | 60   | .....          |
| " 30.....   | 7            | 14           | 6            | 18           | 1            | 46                              | 100         | 57   | .....          |
| " 31.....   | 3            | 4            | 13           | 11           | 5            | 36                              | 100         | 65   | .....          |
| Aug. 1..... | 8            | 7            | 17           | 19           | 4            | 56                              | 100         | 56   | .....          |
| " 2.....    | 5            | 5            | 2            | 7            | 5            | 24                              | 97          | 62   | .....          |
| " 3.....    | 7            | 4            | 2            | 5            | 4            | 22                              | 87          | 63   | .01            |
| " 4.....    | 7            | 11           | 24           | 24           | 6            | 72                              | 93          | 59   | .02            |
| " 5.....    | 7            | 9            | 8            | 9            | 5            | 38                              | 97          | 62   | .....          |
| " 6.....    | 6            | 6            | 15           | 6            | 6            | 39                              | 90          | 59   | .13            |



Table II—Daily Band Record for Season of 1903—Continued

| Date         | No. of Worms | No. of Worms | No. of Worms | No. of Worms | No. of Worms | Total daily No. for the 5 trees | Temperature |      | Precipitation* |
|--------------|--------------|--------------|--------------|--------------|--------------|---------------------------------|-------------|------|----------------|
|              | Gano         | Gano         | Gano         | Gano         | Gano         |                                 | Max.        | Min. |                |
|              | No. 1        | No. 2        | No. 3        | No. 4        | No. 5        |                                 |             |      |                |
| Aug. 7.....  | 6            | 6            | 6            | 3            | 5            | 26                              | 94          | 65   | .....          |
| " 8.....     | 3            | 6            | 13           | 5            | 4            | 31                              | 93          | 60   | .....          |
| " 9.....     | 4            | 7            | 8            | 8            | 1            | 23                              | 95          | 63.5 | .28            |
| " 10.....    | 2            | 8            | 7            | 2            | 2            | 21                              | 93          | 65   | .....          |
| " 11.....    | 1            | 2            | 3            | 3            | 9            | 18                              | 94          | 66   | .....          |
| " 12.....    | 4            | 4            | 10           | 4            | 3            | 25                              | 90          | 67   | .....          |
| " 13.....    | 5            | 5            | 7            | 0            | 1            | 18                              | 91          | 67   | .....          |
| " 14.....    | 0            | 9            | 8            | 2            | 1            | 20                              | 94          | 69   | .30            |
| " 15.....    | 2            | 4            | 4            | 2            | 0            | 12                              | 92          | 65   | .....          |
| " 16.....    | 1            | 0            | 1            | 4            | 2            | 8                               | 93          | 67   | .....          |
| " 17.....    | 4            | 3            | 1            | 8            | 4            | 20                              | 95          | 64   | .....          |
| " 18.....    | 1            | 2            | 4            | 7            | 4            | 18                              | 96          | 66   | .35            |
| " 19.....    | 1            | 5            | 4            | 4            | 0            | 14                              | 93          | 65   | .05            |
| " 20.....    | 3            | 7            | 7            | 2            | 0            | 19                              | 92          | 61   | .04            |
| " 21.....    | 3            | 9            | 6            | 8            | 0            | 21                              | 93          | 59   | .....          |
| " 22.....    | 1            | 3            | 7            | 4            | 0            | 15                              | 96          | 55   | .....          |
| " 23.....    | 1            | 3            | 6            | 2            | 3            | 15                              | 90          | 66   | Trace          |
| " 24.....    | 3            | 4            | 4            | 2            | 1            | 14                              | 92          | 59   | .....          |
| " 25.....    | 1            | 8            | 8            | 2            | 2            | 21                              | 85          | 68   | .07            |
| " 26.....    | 0            | 7            | 7            | 3            | 0            | 15                              | 83          | 66   | .09            |
| " 27.....    | 0            | 8            | 6            | 5            | 4            | 23                              | 88          | 66   | .....          |
| " 28.....    | 3            | 0*           | 5            | 5            | 4            | 17                              | 91          | 65   | .....          |
| " 29.....    | 1            | 5            | 10           | 8            | 1            | 25                              | 90          | 60   | .16            |
| " 30.....    | 1            | 5            | 5            | 1            | 3            | 15                              | 94          | 65   | Trace          |
| " 31.....    | 6            | 2            | 7            | 4            | 1            | 20                              | .....       | 71   | .....          |
| Sept. 1..... | 3            | 0            | 7            | 4            | 0            | 14                              | 91          | 58   | .....          |
| " 2.....     | 3            | 4            | 4            | 0            | 2            | 13                              | 90          | 56   | .....          |
| " 3.....     | 2            | 6            | 4            | 1            | 0            | 13                              | 93          | 58   | .....          |

\* Band was off.

Table II—Daily Band Record for Season of 1903—*Continued*

| Date         | No. of Worms | No. of Worms | No. of Worms | No. of Worms | No. of Worms | Total daily No. for the 5 trees | Temperature |      | Precipitation* |
|--------------|--------------|--------------|--------------|--------------|--------------|---------------------------------|-------------|------|----------------|
|              | Gano No. 1   | Gano No. 2   | Gano No. 3   | Gano No. 4   | Gano No. 5   |                                 | Max.        | Min. |                |
|              |              |              |              |              |              |                                 |             |      |                |
| Sept. 4..... | 3            | 6            | 12           | 0            | 4            | 24                              | 87          | 84   | .....          |
| " 5.....     | 1            | 6            | 0            | 2            | 1            | 10                              | 95          | 85   | .....          |
| " 6.....     | 10           | 4            | 6            | 2            | 1            | 23                              | 91          | 87   | .....          |
| " 7.....     | 5            | 3            | 5            | 1            | 1            | 15                              | 90          | 85   | .....          |
| " 8.....     | 4            | 4            | 2            | 1            | 1            | 12                              | 91          | 86   | .....          |
| " 9.....     | 3            | 5            | 8            | 2            | 4            | 21                              | 90          | 88   | .....          |
| " 10.....    | 5            | 6            | 6            | 4            | 3            | 24                              | 91          | 82   | .....          |
| " 11.....    | 5            | 5            | 7            | 4            | 2            | 23                              | 80          | 84   | .07            |
| " 12.....    | 3            | 4            | 5            | 1            | 0            | 13                              | 89          | 88   | .....          |
| " 13.....    | 2            | 4            | 3            | 0*           | 1            | 10                              | 91          | 86   | .....          |
| " 14.....    | 3            | 4            | 5            | 0*           | 0            | 12                              | 90          | 87   | .....          |
| " 15.....    | 0            | 2            | 3            | 2            | 1            | 8                               | 89          | 89   | .....          |
| " 16.....    | 0            | 3            | 4            | 0            | 1            | 7                               | 83          | 81   | .....          |
| " 17.....    | 1            | 3            | 3            | 0            | 1            | 8                               | 82          | 82   | .....          |
| " 18.....    | 2            | 3            | 0*           | 1            | 0            | 5                               | 90          | 88   | .....          |
| " 19.....    | 1            | 2            | 0*           | 0            | 1            | 4                               | 90          | 84   | .....          |
| " 20.....    | 1            | 3            | 2            | 0            | 1            | 7                               | 86          | 80   | .....          |
| " 21.....    | 1            | 2            | 1            | 1            | 0            | 5                               | 87          | 89   | .85            |
| " 22.....    | 1            | 3            | 1            | 0            | 1            | 5                               | 80          | 80   | .....          |
| " 23.....    | 3            | 3            | 4            | 1            | 0            | 11                              | 88          | 85   | .....          |
| " 24.....    | 2            | 3            | 2            | 2            | 1            | 10                              | 81          | 87   | .91            |
| " 25.....    | 3            | 2            | 3            | 3            | 0            | 11                              | 80          | 86   | .56            |
| " 26.....    | 7            | 0            | 0            | 2            | 1            | 10                              | 87          | 82   | .....          |
| " 27.....    | 1            | 4            | 5            | 1            | 2            | 13                              | 61          | 84   | .82            |
| " 28.....    | 0            | 1            | 7            | 1            | 0            | 9                               | 72          | 86   | .02            |
| " 29.....    | 2            | 3            | 0            | 1            | 1            | 7                               | 78          | 83   | .....          |
| " 30.....    | 1            | 1            | 0            | 0            | 0            | 2                               | 79          | 87   | .....          |
| Oct. 1.....  | 0            | 1            | 0            | 0            | 1            | 2                               | 82          | 87   | .....          |

\* Bands off.

Table II—Daily Band Record for Season of 1903—*Continued*

| Date                            |         | No. of<br>Worms | No. of<br>Worms | No. of<br>Worms | No. of<br>Worms | No. of<br>Worms | Total<br>daily<br>No. for<br>the 5<br>trees | Temper-<br>ature |       | Precipi-<br>tation* |
|---------------------------------|---------|-----------------|-----------------|-----------------|-----------------|-----------------|---------------------------------------------|------------------|-------|---------------------|
|                                 |         | Gano            | Gano            | Gano            | Gano            | Gano            |                                             | Max.             | Min.  |                     |
|                                 |         | No. 1           | No. 2           | No. 3           | No. 4           | No. 5           |                                             |                  |       |                     |
| Oct.                            | 2.....  | 1               | 0               | 3               | 0               | 0               | 4                                           | 87               | 47    | .....               |
| "                               | 3.....  | 0               | 2               | 2               | 1               | 0               | 5                                           | 87               | 45    | .....               |
| "                               | 4.....  | 1               | 0               | 1               | 0               | 1               | 3                                           | 80               | 47    | .....               |
| "                               | 5.....  | 0               | 1               | 0               | 0               | 2               | 3                                           | 85               | 42    | .....               |
| "                               | 6.....  | 0               | 0               | 0               | 1               | 0               | 1                                           | 82               | 37    | .....               |
| "                               | 7.....  | 0               | 0               | 0               | 1               | 0               | 1                                           | 81               | 44    | .....               |
| "                               | 8.....  | 0               | 1               | 0               | 1               | 1               | 3                                           | 82               | 42    | .....               |
| "                               | 9.....  | 1               | 0               | 2               | 0               | 0               | 3                                           | 85               | 49    | .....               |
| "                               | 10..... | 2               | 0               | 0               | 0               | 1               | 3                                           | 88               | 48    | .....               |
| "                               | 11..... | 0               | 1               | 0               | 0               | 1               | 2                                           | 83               | 41    | .....               |
| "                               | 12..... | 0               | 0               | 0               | 1               | 1               | 2                                           | 74               | 40    | .....               |
| "                               | 13..... | 0               | 0               | 1               | 0               | 1               | 2                                           | 76               | 38    | .....               |
| "                               | 14..... | 0               | 0               | 0               | 0               | 0               | 0                                           | 80               | 39    | .....               |
| "                               | 15..... | 0               | 1               | 0               | 0               | 0               | 1                                           | 77               | 35    | .....               |
| "                               | 16..... | 0               | 0               | 0               | 0               | 0               | 0                                           | 71               | 34    | .....               |
| "                               | 17..... | 0               | 0               | 0               | 0               | 0               | 0                                           | 77               | 33    | .....               |
| "                               | 18..... | 0               | 0               | 0               | 0               | 1               | 1                                           | 75               | 33    | .....               |
| "                               | 19..... | 0               | 2               | 0               | 0               | 0               | 2                                           | 78               | 33    | .....               |
| "                               | 20..... | 0               | 0               | 0               | 0               | 0               | 0                                           | 80               | 32    | .....               |
| Total per tree<br>during season |         | 322             | 487             | 632             | 579             | 234             | 2354                                        | .....            | ..... | .....               |

\* The temperature and the precipitation data have been taken from the meteorological records in the Department of Soil Physics of this institution. The observations were made by Mr. Rex Hart, student assistant, under the direction of Professor J. D. Tinsley.

Table III—Daily Band Record for Season of 1904

| Date        | No. of Worms        | No. of Worms | No. of Worms | No. of Worms | No. of Worms | Total daily No. for the 5 trees | Temperature |      | Precipitation* |
|-------------|---------------------|--------------|--------------|--------------|--------------|---------------------------------|-------------|------|----------------|
|             | Kentucky Red Streak |              |              | Northern Spy |              |                                 | Max.        | Min. |                |
|             | No. 1               | No. 2        | No. 3        | No. 4        | No. 5        |                                 |             |      |                |
| May 20..... | 0                   | 1            | 0            | 0            | 0            | 1                               | 88          | 47   |                |
| " 21.....   | 1                   | 2            | 0            | 0            | 0            | 3                               | 87          | 46   |                |
| " 22.....   | 0                   | 1            | 0            | 0            | 0            | 1                               | 88          | 46   |                |
| " 23.....   | 0                   | 1            | 1            | 0            | 0            | 2                               | 91          | 45   |                |
| " 24.....   | 1                   | 1            | 0            | 0            | 1            | 3                               | 83          | 54   | .08            |
| " 25.....   | 1                   | 1            | 0            | 0            | 1            | 3                               | 87          | 59   |                |
| " 26.....   | 0                   | 0            | 0            | 0            | 0            | 0                               | 91          | 51   |                |
| " 27.....   | 0                   | 0            | 0            | 0            | 0            | 0                               | 91          | 51   |                |
| " 28.....   | 0                   | 0            | 0            | 0            | 1            | 1                               | 89          | 51   |                |
| " 29.....   | 1                   | 0            | 0            | 1            | 1            | 3                               | 91          | 50   |                |
| " 30.....   | 0                   | 1            | 0            | 1            | 1            | 3                               | 96          | 49   |                |
| " 31.....   | 0                   | 1            | 2            | 0            | 0            | 3                               | 93          | 57   |                |
| June 1..... | 0                   | 1            | 2            | 1            | 0            | 4                               | 92          | 50   |                |
| " 2.....    | 0                   | 0            | 3            | 0            | 2            | 5                               | 91          | 55   |                |
| " 3.....    | 0                   | 2            | 2            | 0            | 4            | 8                               | 92          | 66   |                |
| " 4.....    | 0                   | 0            | 1            | 0            | 0            | 1                               | 90          | 60   |                |
| " 5.....    | 0                   | 1            | 2            | 0            | 0            | 3                               | 90          | 53   |                |
| " 6.....    | 0                   | 1            | 3            | 0            | 0            | 4                               | 90          | 54   |                |
| " 7.....    | 0                   | 0            | 1            | 1            | 1            | 3                               | 95          | 68   | Trace          |
| " 8.....    | 0                   | 2            | 3            | 0            | 1            | 6                               | 90          | 54   |                |
| " 9.....    | 0                   | 1            | 3            | 1            | 0            | 5                               | 92          | 48   |                |
| " 10.....   | 0                   | 0            | 3            | 1            | 0            | 4                               | 94          | 60   |                |
| " 11.....   | 1                   | 1            | 1            | 0            | 0            | 3                               | 99          | 54   |                |
| " 12.....   | 0                   | 1            | 0            | 4            | 2            | 7                               | 94          | 70   |                |
| " 13.....   | 0                   | 1            | 2            | 0            | 0            | 3                               | 93          | 67   | .12            |
| " 14.....   | 0                   | 0            | 0            | 0            | 0            | 0                               | 90          | 61   | .08            |
| " 15.....   | 0                   | 0            | 1            | 0            | 0            | 1                               | 92          | 56   |                |
| " 16.....   | 0                   | 1            | 1            | 0            | 0            | 2                               | 91          | 62   | Trace          |
| " 17.....   | 1                   | 0            | 0            | 0            | 1            | 2                               | 98          | 63   | Trace          |

Table III—Daily Band Record for Season of 1904—Continued

| Date         | No. of Worms        | No. of Worms | No. of Worms | No. of Worms | No. of Worms | Total daily No. for the 6 trees | Temperature |      | Precipitation* |
|--------------|---------------------|--------------|--------------|--------------|--------------|---------------------------------|-------------|------|----------------|
|              | Kentucky Red Streak |              |              | Northern Spy |              |                                 | Max.        | Min. |                |
|              | No. 1               | No. 2        | No. 3        | No. 4        | No. 5        |                                 |             |      |                |
| June 18..... | 0                   | 4            | 0            | 1            | 1            | 6                               | 95          | 68   | Trace          |
| " 19.....    | 2                   | 5            | 1            | 3            | 1            | 12                              | 97          | 56   | .....          |
| " 20.....    | 1                   | 7            | 0            | 2            | 4            | 14                              | 100         | 61   | .....          |
| " 21.....    | 1                   | 11           | 0            | 4            | 2            | 18                              | 99          | 74   | .....          |
| " 22.....    | 0                   | 5            | 1            | 10           | 2            | 18                              | 97          | 65   | .....          |
| " 23.....    | 1                   | 6            | 1            | 1            | 2            | 11                              | 97          | 65   | .....          |
| " 24.....    | 0                   | 1            | 3            | 0            | 2            | 6                               | 97          | 57   | .....          |
| " 25.....    | 0                   | 1            | 0            | 0            | 5            | 6                               | 98          | 60   | Trace          |
| " 26.....    | 0                   | 2            | 1            | 0            | 4            | 7                               | 88          | 62   | .55            |
| " 27.....    | 1                   | 1            | 0            | 0            | 5            | 7                               | 87          | 58   | .....          |
| " 28.....    | 0                   | 2            | 3            | 1            | 5            | 11                              | 94          | 61   | .....          |
| " 29.....    | 0                   | 2            | 3            | 0            | 8            | 13                              | 100         | 62   | Trace          |
| " 30.....    | 0                   | 2            | 3            | 0            | 4            | 9                               | 98          | 62   | Trace          |
| July 1.....  | 0                   | 4            | 4            | 1            | 11           | 20                              | 94          | 67   | .72            |
| " 2.....     | 0                   | 4            | 4            | 0            | 6            | 14                              | 91          | 57   | .....          |
| " 3.....     | 0                   | 1            | 5            | 0            | 2            | 8                               | 95          | 65   | .....          |
| " 4.....     | 1                   | 2            | 2            | 1            | 6            | 12                              | 100         | 60   | .....          |
| " 5.....     | 2                   | 4            | 7            | 0            | 6            | 19                              | 100         | 62   | .....          |
| " 6.....     | 1                   | 6            | 6            | 4            | 13           | 30                              | 98          | 56   | .....          |
| " 7.....     | 0                   | 1            | 6            | 0            | 15           | 22                              | 95          | 57   | .....          |
| " 8.....     | 0                   | 8            | 2            | 3            | 11           | 24                              | 98          | 58   | Trace          |
| " 9.....     | 0                   | 1            | 5            | 4            | 10           | 20                              | 94          | 69   | .....          |
| " 10.....    | 2                   | 13           | 5            | 5            | 11           | 36                              | 97          | 64   | .....          |
| " 11.....    | 4                   | 4            | 7            | 6            | 10           | 31                              | 101         | 65   | Trace          |
| " 12.....    | 1                   | 8            | 5            | 0            | 13           | 27                              | 98          | 72   | Trace          |
| " 13.....    | 1                   | 1            | 3            | 8            | 9            | 22                              | 101         | 64   | .....          |
| " 14.....    | 3                   | 4            | 7            | 4            | 12           | 30                              | 101         | 62   | .....          |
| " 15.....    | 2                   | 5            | 0            | 4            | 5            | 16                              | 98          | 70   | Trace          |
| " 16.....    | 4                   | 5            | 1            | 3            | 13           | 26                              | 95          | 69   | .....          |

Table III—Daily Band Record for Season of 1904—Continued

| Date |         | No. of Worms        | No. of Worms | No. of Worms | No. of Worms | No. of Worms | Total daily No. for the 5 trees | Temperature |      | Precipitation* |
|------|---------|---------------------|--------------|--------------|--------------|--------------|---------------------------------|-------------|------|----------------|
|      |         | Kentucky Red Streak |              |              | Northern Spy |              |                                 | Max.        | Min. |                |
|      |         | No. 1               | No. 2        | No. 3        | No. 4        | No. 5        |                                 |             |      |                |
| July | 17..... | 0                   | 1            | 0            | 8            | 8            | 17                              | 95          | 69   | .15            |
| "    | 18..... | 0                   | 1            | 2            | 4            | 8            | 15                              | 90          | 66   | .26            |
| "    | 19..... | 0                   | 3            | 1            | 6            | 3            | 13                              | 85          | 64   | .....          |
| "    | 20..... | 2                   | 1            | 1            | 8            | 4            | 16                              | 89          | 61   | Trace          |
| "    | 21..... | 3                   | 1            | 0            | 10           | 8            | 22                              | 91          | 64   | .18            |
| "    | 22..... | 4                   | 2            | 2            | 13           | 9            | 30                              | 90          | 68   | .....          |
| "    | 23..... | 4                   | 0            | 3            | 10           | 3            | 20                              | 88          | 61   | .....          |
| "    | 24..... | 3                   | 2            | 3            | 9            | 1            | 18                              | 89          | 61   | .....          |
| "    | 25..... | 3                   | 4            | 1            | 8            | 11           | 27                              | 91          | 68   | .....          |
| "    | 26..... | 0                   | 2            | 1            | 6            | 2            | 11                              | 93          | 68   | .06            |
| "    | 27..... | 1                   | 8            | 0            | 7            | 6            | 22                              | 94          | 63   | .....          |
| "    | 28..... | 2                   | 5            | 0            | 2            | 10           | 19                              | 96          | 71   | .....          |
| "    | 29..... | 3                   | 3            | 1            | 6            | 4            | 17                              | 98          | 66   | .....          |
| "    | 30..... | 2                   | 2            | 2            | 4            | 5            | 15                              | 98          | 71   | .....          |
| "    | 31..... | 4                   | 1            | 3            | 6            | 3            | 17                              | 95          | 68   | .....          |
| Aug. | 1.....  | 2                   | 1            | 2            | 3            | 1            | 9                               | 94          | 67   | .30            |
| "    | 2.....  | 0                   | 1            | 2            | 2            | 3            | 8                               | 89          | 65   | .07            |
| "    | 3.....  | 4                   | 2            | 2            | 3            | 5            | 16                              | 93          | 67   | .....          |
| "    | 4.....  | 0                   | 1            | 1            | 1            | 2            | 5                               | 92          | 66   | .10            |
| "    | 5.....  | 2                   | 5            | 3            | 5            | 5            | 20                              | 85          | 65   | Trace          |
| "    | 6.....  | 1                   | 3            | 4            | 2            | 0            | 10                              | 79          | 65   | .09            |
| "    | 7.....  | 2                   | 0            | 2            | 3            | 3            | 10                              | 91          | 58   | .....          |
| "    | 8.....  | 2                   | 1            |              | 3            | 3            | 11                              | 91          | 61   | .....          |
| "    | 9.....  | 2                   | 4            |              | 5            | 5            | 19                              | 91          | 64   | .....          |
| "    | 10..... | 2                   | 1            |              | 2            | 5            | 12                              | 92          | 67   | .....          |
| "    | 11..... | 1                   | 2            | 3            | 3            | 8            | 17                              | 90          | 66   | .....          |
| "    | 12..... | 1                   | 1            | 3            | 2            | 4            | 11                              | 91          | 62   | .....          |
| "    | 13..... | 2                   | 4            | 3            | 3            | 6            | 18                              | 92          | 62   | .07            |
| "    | 14..... | 0                   | 0            | 0            | 6            | 8            | 14                              | 92          | 61   | .15            |

Table III—Daily Band Record for Season of 1904—*Continued*

| Date         | No. of Worms        | No. of Worms | No. of Worms | No. of Worms | No. of Worms | Total daily No. for the 5 trees | Temperature |      | Precipitation* |
|--------------|---------------------|--------------|--------------|--------------|--------------|---------------------------------|-------------|------|----------------|
|              | Kentucky Red Streak |              |              | Northern Spy |              |                                 | Max.        | Min. |                |
|              | No. 1               | No. 2        | No. 3        | No. 4        | No. 5        |                                 |             |      |                |
| Aug. 15..... | 0                   | 3            | 1            | 5            | 5            | 14                              | 96          | 63   | .....          |
| " 16.....    | 2                   | 1            | 5            | 5            | 4            | 17                              | 94          | 58   | .....          |
| " 17.....    | 1                   | 0            | 2            | 3            | 2            | 8                               | 89          | 59   | Trace          |
| " 18.....    | 2                   | 3            | 5            | 4            | 3            | 17                              | 93          | 66   | .....          |
| " 19.....    | 2                   | 3            | 6            | 6            | 3            | 20                              | 94          | 67   | Trace          |
| " 20.....    | 0                   | 2            | 3            | 0            | 3            | 8                               | 94          | 66   | Trace          |
| " 21.....    | 0                   | 1            | 3            | 4            | 0            | 8                               | 94          | 65   | .....          |
| " 22.....    | 0                   | 2            | 3            | 3            | 2            | 10                              | 87          | 65   | .03            |
| " 23.....    | 0                   | 1            | 4            | 4            | 3            | 12                              | 91          | 70   | .....          |
| " 24.....    | 2                   | 2            | 1            | 1            | 0            | 6                               | 92          | 62   | .....          |
| " 25.....    | 2                   | 2            | 1            | 0            | 1            | 6                               | 94          | 58   | .....          |
| " 26.....    | 1                   | 1            | 1            | 0            | 2            | 5                               | 89          | 65   | .43            |
| " 27.....    | 1                   | 1            | 2            | 0            | 1            | 5                               | 90          | 61   | .....          |
| " 28.....    | 2                   | 1            | 2            | 3            | 7            | 15                              | 94          | 59   | .....          |
| " 29.....    | 4                   | 1            | 2            | 4            | 3            | 14                              | 96          | 58   | .....          |
| " 30.....    | 0                   | 2            | 5            | 4            | 2            | 13                              | 95          | 59   | .....          |
| " 31.....    | 1                   | 4            | 2            | 4            | 7            | 18                              | 96          | 58   | .....          |
| Sept. 1..... | 4                   | 4            | 3            | 0            | 4            | 15                              | 97          | 56   | .....          |
| " 2.....     | 0                   | 3            | 7            | 1            | 4            | 15                              | 93          | 56   | .19            |
| " 3.....     | 3                   | 6            | 9            | 5            | 2            | 25                              | 76          | 63   | .15            |
| " 4.....     | 4                   | 3            | 6            | 9            | 3            | 25                              | 67          | 60   | .12            |
| " 5.....     | 5                   | 4            | 4            | 8            | 5            | 26                              | 74          | 58   | Trace          |
| " 6.....     | 3                   | 3            | 1            | 2            | 7            | 16                              | 76          | 58   | .....          |
| " 7.....     | 2                   | 3            | 4            | 4            | 2            | 15                              | 65          | 56   | .22            |
| " 8.....     | 1                   | 3            | 6            | 6            | 4            | 20                              | 80          | 57   | .....          |
| " 9.....     | 1                   | 3            | 5            | 3            | 2            | 14                              | 82          | 62   | .....          |
| " 10.....    | 0                   | 4            | 6            | 3            | 2            | 15                              | 88          | 58   | .....          |
| " 11.....    | 1                   | 3            | 3            | 2            | 1            | 10                              | 88          | 60   | .....          |
| " 12.....    | 1                   | 3            | 2            | 1            | 1            | 8                               | 89          | 58   | 1.23           |

Table III—Daily Band Record for Season of 1904—Continued

| Date          | No. of Worms        | No. of Worms | No. of Worms | No. of Worms | No. of Worms | Total daily No. for the 5 trees | Temperature |      | Precipitation* |
|---------------|---------------------|--------------|--------------|--------------|--------------|---------------------------------|-------------|------|----------------|
|               | Kentucky Red Streak |              |              | Northern Spy |              |                                 | Max.        | Min. |                |
|               | No. 1               | No. 2        | No. 3        | No. 4        | No. 5        |                                 |             |      |                |
| Sept. 13..... | 0                   | 0            | 2            | 1            | 2            | 5                               | 84          | 53   | .07            |
| " 14.....     | 1                   | 0            | 1            | 1            | 3            | 6                               | 75          | 61   | .....          |
| " 15.....     | 0                   | 2            | 4            | 1            | 1            | 8                               | 76          | 57   | .....          |
| " 16.....     | 2                   | 2            | 2            | 0            | 1            | 7                               | 86          | 55   | .....          |
| " 17.....     | 2                   | 6            | 3            | 1            | 2            | 14                              | 89          | 59   | .....          |
| " 18.....     | 0                   | 1            | 1            | 1            | 0            | 3                               | 91          | 55   | .....          |
| " 19.....     | 1                   | 2            | 3            | 2            | 4            | 12                              | 92          | 56   | .....          |
| " 20.....     | 1                   | 0            | 1            | 1            | 1            | 4                               | 85          | 58   | .41            |
| " 21.....     | 1                   | 3            | 1            | 0            | 2            | 7                               | 81          | 56   | .....          |
| " 22.....     | 0                   | 2            | 1            | 1            | 4            | 8                               | 86          | 56   | .....          |
| " 23.....     | 1                   | 0            | 1            | 1            | 1            | 4                               | 83          | 52   | Trace          |
| " 24.....     | 3                   | 1            | 5            | 1            | 1            | 11                              | 87          | 57   | .....          |
| " 25.....     | 0                   | 0            | 2            | 0            | 1            | 3                               | 91          | 66   | .....          |
| " 26.....     | 0                   | 0            | 1            | 0            | 1            | 2                               | 92          | 63   | Trace          |
| " 27.....     | 0                   | 2            | 3            | 0            | 3            | 6                               | 90          | 60   | Trace          |
| " 28.....     | 2                   | 0            | 3            | 0            | 3            | 8                               | 86          | 56   | .....          |
| " 29.....     | 1                   | 3            | 0            | 0            | 3            | 7                               | 77          | 63   | 1.63           |
| " 30.....     | 1                   | 2            | 1            | 1            | 0            | 5                               | 78          | 54   | .....          |
| Oct. 1.....   | 2                   | 1            | 4            | 0            | 2            | 9                               | 84          | 58   | .60            |
| " 2.....      | 2                   | 2            | 0            | 1            | 0            | 5                               | 82          | 59   | .....          |
| " 3.....      | 1                   | 2            | 1            | 1            | 3            | 8                               | 80          | 61   | .....          |
| " 4.....      | 0                   | 3            | 4            | 0            | 0            | 7                               | 84          | 57   | .....          |
| " 5.....      | 0                   | 2            | 0            | 0            | 0            | 2                               | 88          | 54   | .....          |
| " 6.....      | 0                   | 1            | 1            | 0            | 0            | 2                               | 75          | 63   | .....          |
| " 7.....      | 3                   | 1            | 1            | 0            | 4            | 9                               | 80          | 57   | .41            |
| " 8.....      | 0                   | 0            | 2            | 1            | 1            | 4                               | 69          | 62   | .10            |
| " 9.....      | 1                   | 1            | 1            | 0            | 2            | 5                               | 74          | 56   | .....          |
| " 10.....     | 1                   | 0            | 2            | 1            | 1            | 7                               | 78          | 43   | .....          |
| " 11.....     | 2                   | 0            | 1            | 0            | 1            | 4                               | 89          | 53   | .....          |



Table III—Daily Band Record for Season of 1904—Continued

| Date         | No. of<br>Worms     | No. of<br>Worms | No. of<br>Worms | No. of<br>Worms | No. of<br>Worms | Total<br>daily<br>No. for<br>the 5<br>trees | Temper-<br>ature |      | Precipitation* |
|--------------|---------------------|-----------------|-----------------|-----------------|-----------------|---------------------------------------------|------------------|------|----------------|
|              | Kentucky Red Streak |                 |                 | Northern Spy    |                 |                                             | Max.             | Min. |                |
|              | No 1                | No. 2           | No. 3           | No. 4           | No. 5           |                                             |                  |      |                |
| Oct. 12..... | 4                   | 0               | 0               | 0               | 3               | 7                                           | 82               | 52   | .....          |
| " 13.....    | 2                   | 0               | 0               | 0               | 1               | 3                                           | 83               | 45   | .....          |
| " 14.....    | 0                   | 1               | 0               | 0               | 0               | 1                                           | 83               | 49   | .13            |
| " 15.....    | 0                   | 0               | 0               | 0               | 1               | 1                                           | 77               | 58   | .....          |
| " 16.....    | 0                   | 0               | 0               | 0               | 1               | 1                                           | 78               | 53   | .....          |
| " 17.....    | 1                   | 0               | 0               | 0               | 0               | 1                                           | 79               | 56   | .....          |
| " 18.....    | 0                   | 0               | 0               | 0               | 0               | 0                                           | 68               | 45   | .....          |
| " 19.....    | 0                   | 0               | 1               | 0               | 0               | 1                                           | 65               | 36   | .....          |
| " 20.....    | 0                   | 0               | 0               | 0               | 0               | 0                                           | 64               | 32   | .....          |
| " 21.....    | 0                   | 0               | 0               | 1               | 0               | 1                                           | 75               | 31   | .....          |
| " 22.....    | 0                   | 0               | 0*              | 0               | 0               | 0                                           | 78               | 37   | .....          |
| " 23.....    | 0                   | 0               | 0               | 0               | 0               | 0                                           | 74               | 40   | .....          |
| " 24.....    | 0                   | 0               | 0               | 0               | 0               | 0                                           | 68               | 49   | .17            |
| " 25.....    | 0                   | 0               | 0               | 1               | 0               | 1                                           | 54               | 42   | .....          |
| " 26.....    | 0                   | 0               | 0               | 0               | 0               | 0                                           | 58               | 34   | .....          |
| " 27.....    | 0                   | 0               | 0               | 0               | 0               | 0                                           | 64               | 30   | .....          |
| " 28.....    | 0                   | 0               | 0               | 0               | 0               | 0                                           | 65               | 33   | Trace          |
| " 29.....    | 0                   | 0               | 0               | 0               | 0               | 0                                           | 64               | 37   | .02            |
| " 30.....    | 0                   | 0               | 0               | 0               | 0               | 0                                           | 60               | 41   | .10            |
| " 31.....    | 0                   | 0               | 0               | 0               | 0               | 0                                           | 63               | 33   | .....          |
| Nov. 1.....  | 9                   | 0               | 0               | 0               | 0               | 0                                           | 64               | 33   | .....          |
| " 2.....     | 0                   | 0               | 0               | 0               | 0               | 0                                           | 68               | 31   | .....          |
| " 3.....     | 0                   | 0               | 1               | 0               | 0               | 1                                           | 67               | 29   | .....          |
| " 4.....     | 0                   | 0               | 0               | 0               | 0               | 0                                           | 67               | 40   | .50            |
| " 5.....     | 0                   | 0               | 0               | 0               | 0               | 0                                           | 62               | 31   | .....          |
| " 6.....     | 0                   | 0               | 0               | 0               | 0               | 0                                           | 66               | 32   | .....          |
| " 7.....     | 0                   | 0               | 0               | 0               | 0               | 0                                           | 66               | 34   | .....          |
| " 8.....     | 0                   | 0               | 0               | 1               | 0               | 1                                           | 65               | 32   | .....          |
| " 9.....     | 1                   | 0               | 1               | 0               | 0               | 2                                           | 70               | 29   | .....          |

**Table III—Daily Band Record for Season of 1904—Continued**

| Date             | No. of Worms        | No. of Worms | No. of Worms | No. of Worms | No. of Worms | Total daily No. for the 5 trees | Temperature |       | Precipitation* |
|------------------|---------------------|--------------|--------------|--------------|--------------|---------------------------------|-------------|-------|----------------|
|                  | Kentucky Red Streak |              |              | Northern Spy |              |                                 | Max.        | Min.  |                |
|                  | No. 1               | No. 2        | No. 3        | No. 4        | No. 5        |                                 |             |       |                |
| Nov. 10.....     | 0                   | 0            | 0            | 0            | 0            | 0                               | 50          | 33    | .....          |
| " 11.....        | 0                   | 0            | 0            | 0            | 0            | 0                               | 48          | 30    | .....          |
| " 12.....        | 0                   | 0            | 0            | 0            | 0            | 0                               | 37          | 17    | .....          |
| Season's totals. | 166                 | 318          | 326          | 338          | 463          | 1641                            | .....       | ..... | .....          |

\* The temperature and the precipitation data have been taken from the meteorological records in the Department of Soil Physics of this institution. The observations were made by Mr. Rex Hart, student assistant, under the direction of Professor J. D. Tinsley.

Table I shows the weekly and total weekly number of worms on each of the four Ben Davis trees in 1903. In tables II and III the daily and total daily number of worms are given for each of the five trees observed during the years 1903 and 1904. The maximum and minimum temperatures and the precipitation, which have been taken from the meteorological data in the Soil Physics Department of this institution, are also given.

By studying these tables it will be seen that neither the changes in temperature nor the rainy weather affected materially the worms from coming out of the apples. The common opinion has been that changes in weather conditions would temporarily delay the larvæ from leaving the apples. Judging from the figures in the tables, the worms seem not to have been affected by variations in the weather.

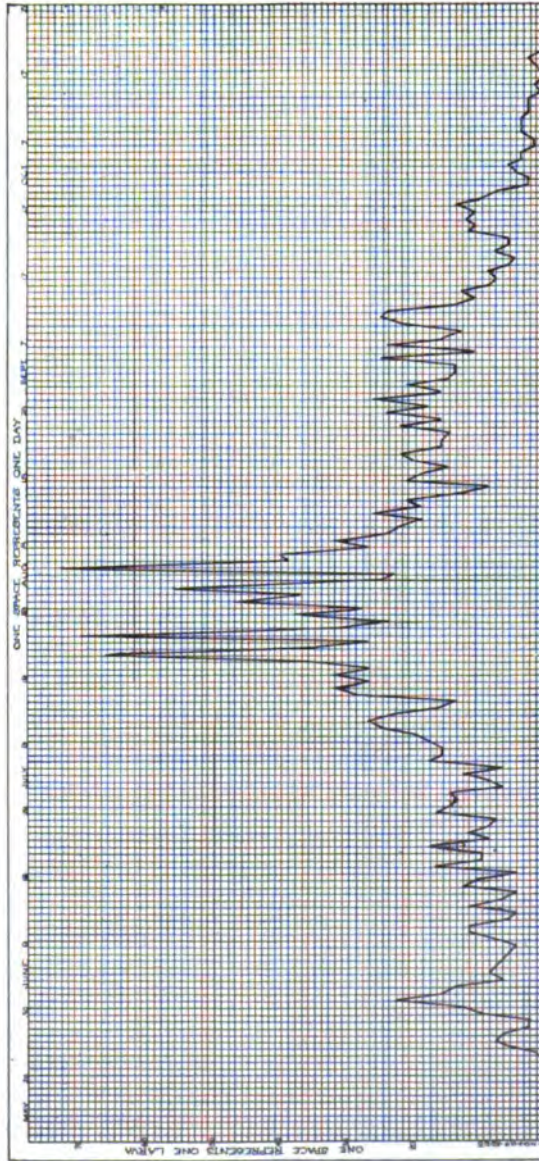


Diagram I-Daily Band Record for 1903.

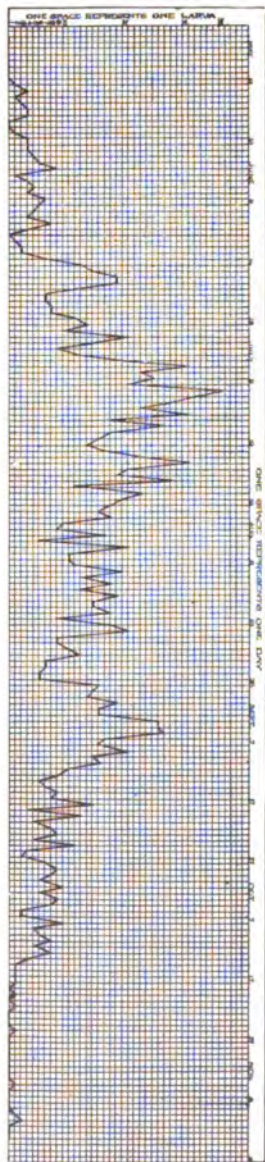
In Table II it is seen that the first week in June was more or less rainy, and that there was a drop in the number of

larvæ recorded. This decrease in the number of larvæ must have been due to the fact that the maximum from the early brood had just passed. From June 10th to the 14th, it rained every day and the number of larvæ recorded during these five days, is slightly less than for the following five days, when, with the exception of one day, the weather was fair. It is interesting to note, also, that July 25th and August 4th, 1903, the two days when the largest number of larvæ were recorded, were rainy days.

Table III also shows that changes in the weather had no effect upon the worms leaving the apples. During some rainy days the number of larvæ recorded was very low, while during other rainy days the number was high. It is noticed that September 3d, 4th and 5th, when the maximum from the third brood was recorded, were rainy days.

All the three tables show that there was a marked variation in the number of larvæ recorded, under each band, at every observation. Some days one tree would have more than the others, while the next time the trees that had had the most would probably have less.

Diagram II—Daily Band Record for 1904.



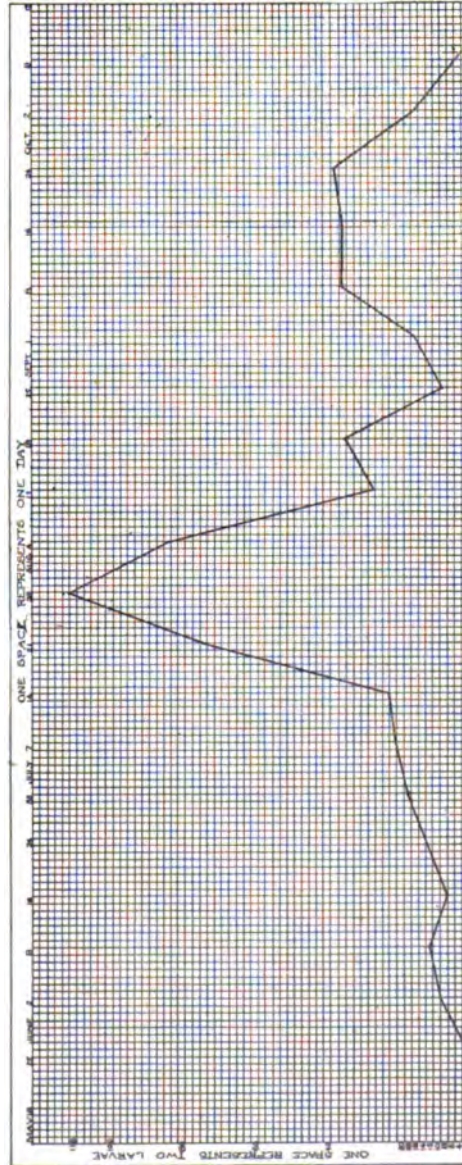


Diagram III - Weekly Band Record for 1903.



Both the tables and diagrams show the irregularity of the hatching out and the decided tendency of the broods to overlap. There is no distinct demarcation between the ending of one brood and the beginning of the next one, though the maximums in most cases are quite well marked.

It will be seen that the records can be more clearly given in the three diagrams. In diagram I and II each vertical space represents one larva and each horizontal space represents one day. According to diagram I, the maximum number of larvæ for the first brood was recorded on May 31st. On July 22nd and 25th two maximum numbers of larvæ for the second brood were recorded. Another maximum number of larvæ which seems to be a part or continuation of the second brood, appeared on August 4th. It is seen that there is a marked break in the appearance of the maximum number of larvæ of the second brood. A change in weather conditions was first thought to be the cause of this peculiar break or variation. According to the weather records given for these dates the marked variation can hardly be due to weather conditions. It is also noticed that the curve drops down considerably and very abruptly after August 4th. From September 4th to the 11th there is more or less of a rise in the curve which seems to indicate a slight or partial third brood.

If fifty days are taken for the life period of the insect it will be seen that the second maximum of larvæ began to appear about fifty days after the maximum of the first brood was recorded. The maximum of what seems to be a partial third brood appeared just fifty days after the maximum of the second brood began.

The records show the dates of the appearance of the larvæ after they had left the apples. The approximate date when the maximum number of larvæ from each brood were ready to go into the apple may be found by counting back about 19 days for the time the worms remain inside of the fruit. Then, according to this, the maximum number of larvæ for the first, second, and partial third broods were ready to enter the

apples in 1903 about May 12th, July 3d, and August 21st respectively.

The maximum of the first brood in diagram II is not as well marked as in diagram I. On June 3d there is a slight elevation, which might be due to the maximum from the first brood. It is noticed in diagram II, the same as in diagram I, that there is a marked break in the appearance of the maximum number of larvæ from the second brood. On July 10th and 22nd two maximum numbers of larvæ from the second brood were recorded. There was a marked break between these two dates. The maximum number of larvæ of what seems to be a well marked third brood was recorded September 3d and 5th. The appearance of the late maximum number of larvæ was somewhat earlier in 1904 than in 1903.

In diagram III, which represents the weekly record for 1903, each vertical space represents two larvæ. It is seen from the diagram that the maximum number of larvæ for the first brood must have appeared sometime between the 2nd and 9th of June. The maximum for the second brood was recorded July 28th, though it is likely that it occurred slightly earlier. The middle maximum number of larvæ for the partial third brood was recorded September 16th. The time between these maximums is about 50 days. The appearance of the maximum number of larvæ for the different broods in diagrams I and III agree quite well.

### Summary

1.—The preliminary study of the life history of the codling moth during 1903 and 1904 was carried on at the Station and the details here given apply only to this locality. The work has not been carried on long enough to draw any definite conclusions.

2.—The daily records for 1903 show a well marked first and second brood with indications of a partial third.

3.—The daily records for 1904 barely show any first maximum number of larvæ, while the maximum for the second and third broods are well marked.

4.—The weekly records for 1903 show more distinctly three different maximum numbers of larvæ than the daily records do.

5.—All the records show that the first brood from the wintered-over larvæ, and what appears to be at least a partial third brood, are very small, while the second brood is exceedingly large.

6.—The time between the appearance of the different maximums recorded in the two seasons varies slightly in a few cases from the fifty day period of the codling moth, though in most cases it is practically fifty days.

7.—The observations agree to some extent with those of other observers with regard to the first moths from the wintered-over larvæ emerging about the time the blossoms have fallen or a little later.

8.—There is a decided tendency of the broods to overlap, as well as a noticeable irregularity in the appearance of the daily number of larvæ.

9.—Weather variations seem not to have affected the larvæ from coming out of the apples.



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**AGRICULTURAL EXPERIMENT STATION**

**AGRICULTURAL COLLEGE, N. M.**

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**THE RANGE PROBLEM**

**IN**

**NEW MEXICO**

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**BY**

**E. O. WOOTON,**

**Botanist**

**ALBUQUERQUE MORNING JOURNAL**

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# **New Mexico Agricultural Experiment Station**

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## Introduction

"The conservation of our natural resources and their proper use constitute the fundamental problem which underlies almost every other problem of our national life. Unless we maintain an adequate material basis for our civilization, we cannot maintain the institutions in which we take so great and so just a pride; and to waste and destroy our natural resources means to undermine this material basis."—Roosevelt.

The duties of Experiment Station Botanist have caused the author to make a critical first-hand study of the range problem in New Mexico—an examination extending over several years, and taking him over the greater portion of the Territory in a wagon or on horseback. He has thus come in close contact with the ranges and the stockmen and has endeavored to see the situation from as many points of view as possible. Being in no way financially interested in the industry, there was little chance of personal bias; the large view tends ever to fairness to the greatest number.

No small part of the work of examination was done in collaboration with the division of Farm Management of the Bureau of Plant Industry, Washington, D. C., and the author desires to acknowledge the assistance of all kinds which has been received from the officers of that division. But for their aid in many ways the following bulletin could not have been as complete as it is, and the author thoroughly appreciates their efforts as well as the individual kindnesses of these gentlemen, and is grateful for them.

The difficulties arising from the present methods of conducting the business on an open public range were apparent on every side, and each individual was able to see clearly those immediately affecting himself and less certainly those of "the other fellow." The author endeavored to get the point of view of each, hoping to summarize the different ideas into something valuable not only to stockmen, but in some measure to all the citizens of the Territory. Such con-

clusions must be in some degree applicable to similar conditions in other states and territories of the union, where stockraising on the public domain is now carried on.

Stockraising is one of the most important industries of the Territory and probably always will be. It is a large part of the "material basis" of our territorial civilization, and is therefore of vital importance not alone to the men engaged in it but to every citizen of our civilization. Whatever will improve the conditions of the stock business and increase the output of beef and mutton, fat cattle and lambs, wool, mohair, and hides, or horses and mules, is bound to increase the general prosperity of the Territory, and make our social conditions better and life more worth living.

This bulletin is an attempt to present a statement of the factors affecting the industry; it is concerned most with those factors due to the natural conditions under which the industry is carried on, and those social and economic conditions which may have arisen as the result of the application to one region, of land laws and customs designed for and properly applicable to another and very dissimilar one.

The author believes that a better method of treatment of our public domain is not only possible, but has already been devised,\* and that all now necessary to cause the adoption of this plan is the complete understanding of it by the general public, and stockmen in particular. Certain individuals will be opposed to it for purely personal reasons, but the fair-minded citizen, be he financially interested or not, will, if the subject be properly presented to him, see the inherent fairness of the proposed plan and recognize the many advantages it possesses over the method of management now in operation.

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\*It was hoped at one time that valuable information upon the subject might be obtained from owners of some of the large grants in the Territory, but it was found on inquiry that the grants had been treated as the public lands because the titles were vested in so many people that managerial authority had been given to no one. The grants have therefore been treated as common property and not cared for at all. Recently a few have been leased and fenced, but data as to results are not yet available.

It seems especially desirable to call the particular attention of the average citizen to this subject. The valley farmer, the business man, the professional man, are all directly interested in the development of the Territory and thus indirectly interested in the advancement of every important industry now forming a part of our territorial civilization.

Much of what is included herein is already known to stockmen, but it is hoped that a plain statement of the situation and its possible ameliorization may be of benefit to many who have thought little or narrowly of the subject. Although the conclusions herein expressed have mostly been reached independently by the author, he makes little claim of originality, since it has all been worked out by others from a number of different standpoints; but all have arrived at very similar conclusions, by the very nature of the case.

Credit cannot be given here for all the ideas received from others, though the author would gladly acknowledge them. The literature of the subject has been consulted as fully as possible, and where quoted full credit is given. But many men are working on the subject and a consideration of it is in the air. A prominent speaker\* has gone so far as to express his belief that some form of government control was not only desirable and right, but that it would be established in the near future. The author is heartily in sympathy with this idea and is sure it can be done with advantage to the stockman, the range, and all others concerned. With this idea in mind the following statement of the case as found in New Mexico is submitted.

### Area and Apportionment

The total area of New Mexico is about 122,580 square miles, or something over  $78\frac{1}{2}$  millions of acres—an area equal in extent to all the New England States, New York, and New Jersey combined; almost as large as Norway, the

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\*Dr. Gifford Pinchot, Chief Forester of the United States, at the Public Lands Convention, Denver, June, 1907.

Philippines, or Italy and Switzerland combined, and more than half as large as France or Germany.

Data obtained from various sources show that the lands are apportioned approximately as follows:

1. Lands held under grants from the Mexican government and confirmed by the authorized U. S. land courts, about  $9\frac{1}{2}$  millions of acres.

2. Lands granted as subsidies to transcontinental railroads, about 4 millions of acres. Some of these holdings have been surrendered for lieu land scrip, and much of the land has been sold.

3. Lands granted to the Territory as an endowment for its schools, charitable, penal and other institutions, about 5 millions of acres. These lands are in charge of a territorial land commission and managed by a commissioner.

4. Lands held under patent from the U. S. government, obtained as homesteads, desert claims, mineral claims, etc., about  $2\frac{1}{2}$  millions of acres.

5. Lands included in forest reserves, Indian and military reservations, and reservations made for the reclamation service, in all about  $8\frac{1}{2}$  millions of acres.

6. Unappropriated or public lands, nearly 50 millions of acres.

It will be seen from the above that there is now open for entry in this Territory about 55 millions of acres of public land;\* and that there are about  $4\frac{1}{2}$  millions of acres now in Indian and other kinds of reservations which may be and probably ultimately will be thrown open for settlement. Probably not over ten per cent of this land ever will be cultivated as agricultural lands. It is safe to say that much the greater part of the arable land as well as that having permanent water upon it is already held under some sort of title.

Mr. F. H. Newell\*\* has classified the lands of the Terri-

\*Agricultural lands within the forest reserves may be homesteaded by bona fide settlers.

\*\*Irrigation, p. 55, 1902. Recent development has increased the amount of improved and irrigated lands very materially.



tory as follows, giving the areas of each kind in millions of acres:

Grazing lands, 57; woodlands, 16; forest, 4; improved,  $1\frac{1}{2}$ ; irrigated,  $1\frac{1}{5}$ ; water supply, 4.

This being interpreted, means that we have a water supply which, if it were all conserved, would be sufficient for the growing of crops on 4 millions of acres. Of all this vast domain 73 per cent is recognized as good for grazing only. But 25 per cent more of it, though properly classed as woodland and forest, is also grazing land, and there is hardly an acre of it which doesn't have stock upon it. So we see that in whatever hands the control of our lands may lie, whatever the crops they may produce, by far the greater portion of them (certainly not less than 90 per cent and probably even more) produces a crop of forage, the gathering of which each year by range stock is an important source of legitimate income to the people of our Territory and probably always will be.

### Topography

Geographically New Mexico is to be considered as a high plateau about 350 miles square, sloping gradually from an elevation of about 6,000 feet above sea level on the northern end to about 3,500 feet at the southern end. It has been correctly spoken of as a part of the roof of the continent for it slopes gently eastward and westward from a north and south line which crosses it just west of the middle. Upon this plateau stand numerous masses and ridges of mountains, generally trending north and south, while through it and between the mountains wind the Rio Grande and Rio Pecos in relatively narrow valleys. Other smaller streams which rise in the mountains flow into these two, out of the Territory, or are lost in the dry sands of the mesas.

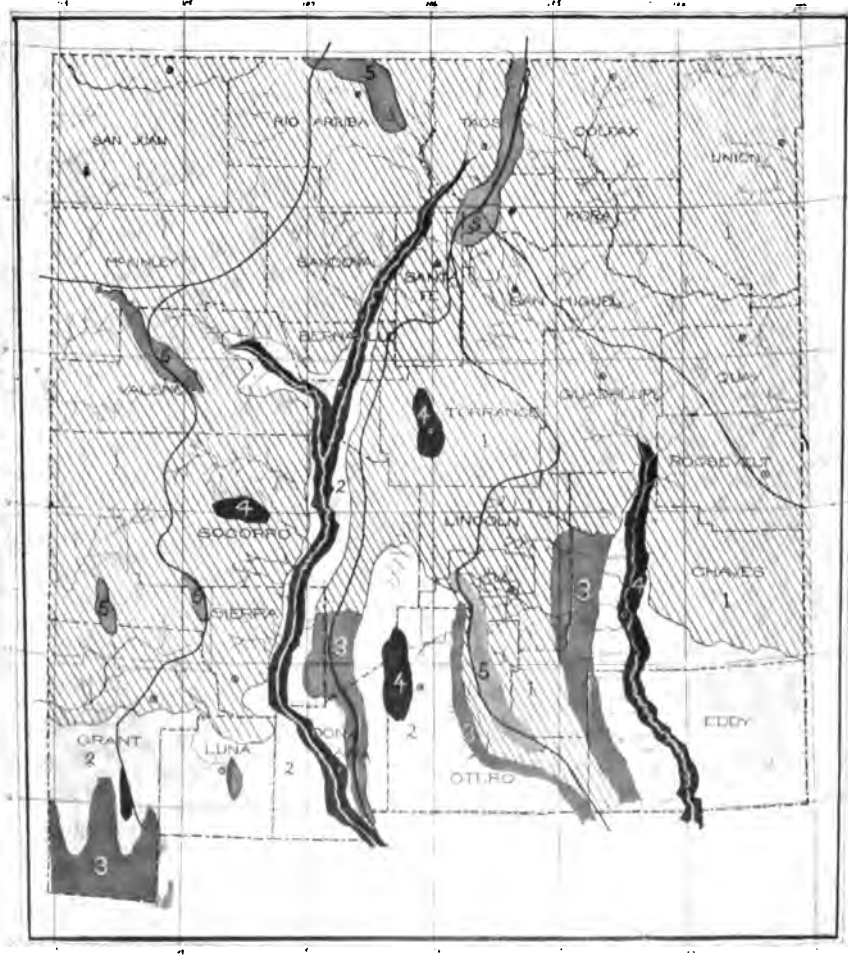
The mountains of the Territory are of two classes which I have chosen to speak of as "ridges" and "masses." By

"ridges" are meant long, relatively narrow ranges, which stand out by themselves and are not of sufficient size and elevation to cause any large increase in precipitation. Such ridges are usually rocky and dry; they produce more forage than the plains, but much of it is composed of low bushes and scrubby trees. Few trees of any size grow upon such mountains and those which do grow are found on the upper, cooler slopes and in the less accessible canyons. Much the greater number of named mountain ranges of the Territory are of this type, which is well exemplified by such ranges as the Florida Mountains, the Organ Mountains, or the Big Hatchet Mountains. The permanent watering places in such mountains consist of springs, seeps, and small streams rarely more than a mile long. Almost all the land upon which permanent water exists is patented and many such claims are occupied by the owners who have stock upon the surrounding public domain.

By "masses" of mountains I have attempted to characterize such areas as the Mogollon-Black Range area, the Sacramento-White Mountain region, or the Glorieta Mountains. Such areas consist of numerous more or less parallel ranges or high plateaus which are twenty-five, fifty, or more miles across and of even greater length. The valleys between the ridges are all at high elevations above the sea and some of the peaks of such a mass usually extend above timber line. They are thus of such size and so high above the surrounding plains that they receive more precipitation, a goodly portion of which is snow. Such mountain masses are usually covered with timber from about the 5,500 feet contour, though the actual line at which timber begins is dependent to some degree upon the exposure. Above 6,000 to 6,500 feet altitude there is normally a good stand of coniferous timber, which extends on up to the timber line, found at from 11,000 to 11,500 feet in most places. The climatic conditions found in such mountainous areas are certainly not truly arid, though they are to some degree affected by the surrounding aridity. There are many fertile little valleys winding through the



**Figure 1. Relief Map of New Mexico, Giving a General View of the More Prominent Topographical Features.**



**Figure 2. An Outline Map of New Mexico Showing the Distribution of the Principal Grass Societies.**

1. The Blue Grama Society. The society in which Blue Grama is the dominant species. It covers the higher plains, the forest, and woodland areas.
2. The Black Grama Society. This is the society which occupies the lower plains of the Territory. The principal grasses are Black Grama, Tobosa, and the Needle Grasses.
3. This society is intermediate between 1 and 2. The characteristic grass is Halcy Grama, which replaces much of the Blue Grama and all of the Black Grama.
4. The Salt Grass Society. Mainly composed of Bunch Grass and Salt Grass, with sedges and rushes in wet situations.
5. The Arizona Fescue Society. The dominant grass is Arizona Fescue. The society usually occurs high in the mountains on open slopes and "burns."

forests and watered by streams of clear water supplied by snow-fed springs. Open glades or parks are not uncommon and furnish excellent pasturage. Most of the arable lands of such valleys, and to some extent the parks, have been patented and are occupied by small farmers who make a comfortable living. Their stock runs on the surrounding public lands.

The typical agricultural valleys of the Territory are narrow strips of land, rarely more, and usually considerably less than ten miles wide, lying along the larger rivers—the Rio Grande, the Rio Pecos, the San Juan, the Gila, and several streams of much less size. The agricultural development of such lands is wholly dependent upon the irrigation water supplied by the streams they parallel.

In the most fundamental sense, the climate, and the topography of a land determine the industries of its inhabitants. The cultivation of farm, garden, and orchard crops is carried on in this Territory wherever there is sufficient tillable land associated with sufficient water to grow marketable crops. But such areas, though in the aggregate amounting to over 1,000,000 acres, constitute a relatively small portion of our vast domain.

There is very little absolutely true desert in the Territory and this consists mainly of relatively recent lava flows, gypsum dunes, and salt flats. A certain small part of the area consists of inaccessible rocky peaks upon which little grows.

Mountains, forests, and dry plains suggest the correlated ideas of mining, lumbering, and stockraising, and the relative importance of each industry is dependent upon the abundance and character of the mineral deposits, the standing timber, and the native forage crops with the relative areas occupied by each. Fortunately for the stock raisers the presence of the natural resources of the other two industries interferes but little with him, for forage plants grow in the forests and over the mineral wealth.

## The Forage Plants

### Grasses and Sedges

Any plant which stock will eat is to be classed as a part of the forage crop of the Territory, and probably 90 per cent of the native plants are eaten more or less. Nearly all kinds of shrubs, most herbaceous annuals and perennials, and not a few trees form at least some part of this crop.

Of course, the most important members of this assemblage are the grasses and their near relatives the sedges, the latter being considered as grass by the stockman. The species differ very much in value for a number of different reasons. Some species are abundant in quantity, good in quality, and are naturally preserved as hay where they stand. These, of course, are by far the most valuable kinds. Some are good only while green and succulent; some are able to grow in unfavorable situations and so produce a crop upon land which would otherwise be barren. These are apt to be relatively poor feed but much better than none. Many of them are produced so scantily as to be of little importance as forage. A few grow in places more or less inaccessible to stock. There is only a single species of grass, the "sleepy grass" (*Stipa Vaseyi* Scribn.) which is not eaten at all upon the range.\* Several species are let alone by stock until hard pressed, but this is usually due to the unpalatable nature of the grass. A few of the species found in the cultivated fields are troublesome weeds, among which the sand-bur is probably the worst.

Approximately 300 species of grasses and sedges have been reported from the Territory, but the great bulk of the forage is furnished by not more than 25 or 30 of these, which are abundant in quantity and good in quality. It is even likely that fully half of the grass crop is composed of a smaller number of species than this.

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\*Cattle and horses learn to leave this grass alone after having experienced its narcotic effects. Whether or not sheep and goats can eat it, I have been unable to learn.

A detailed discussion of the various species would be out of place here, but an attempt to show something of the distribution and, by this, the importance of some of them, is made in the sketch map which accompanies. (Fig. 2) As will be seen by consulting this map certain species of grasses are more or less commonly associated together because they are adapted to similar climatic conditions. Such assemblages of species might be termed grass societies.

Of first importance are the societies which occupy the open plains of the Territory. Attention has already been called to the difference in altitude of the plains and these differences naturally affect the distribution of the grasses. At elevations of from 5,500 to 8,000, or possibly 8,500 feet, any place in the Territory, the most common grass is likely to be the blue grama (*Bouteloua oligostachya* (Nutt.) Torr.). While probably the commonest, it is also one of the best grasses, if not the very best, for all purposes, and it is correspondingly highly prized by the stockman wherever he may run stock. It is the dominant grass on the high plains of the northern and central portions of the Territory where it is most luxuriant. It is also found in the forest and woodland areas wherever the altitude and climatic conditions are favorable. Along the western side of the Territory it is usually associated with the galleta\* grass (*Hilaria Jamesii* (Torr.) Benth.), which is sometimes known as black grama, and is also an excellent, though coarser, range grass. These two together form the bulk of the plains grasses of the northwestern part of the Territory. On the northeastern side both are more or less replaced by buffalo grass (*Bulbils dactyloides* (Nutt.) Raf.) and the combination is a very difficult one to surpass in an arid region. Other grasses of much less value commonly occur with these, adding slightly to the forage crop. None of them are sufficiently assertive to drive out the better grasses, so they are rarely the dominant species of a range, except when that

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\*Pronounced gah-yet'-ta.

range has been badly overstocked. Several species of needle grass (*Aristida* spp.), a small tufted grass without a common name (*Muhlenbergia gracillima* Torr.), Colorado blue-stem (*Agropyron occidentale* Scribn.) to some extent, and a few others of less importance belong to this society.

On the plains of the southern end of the Territory, occupying approximately one-fifth of the total area, is another grass society closely related to the preceding. The grasses of this society are the true black grama (*Bouteloua eriopoda* Torr., sometimes called woolly-jointed grama), which occupies the place on the sandy, hotter, and drier plains that is filled by the blue grama farther north; the tobosa grass (*Hilaria mutica* (Buckl.) Benth.), the drier region equivalent of the galleta grass; and a small grass which in several respects suggests the buffalo grass\* of further north—sometimes called needle grass (*Scleropogon brevifolius* Phillippi). Ranges occupied by these grasses are not as valuable as those producing the first named society because the grasses are not such good feed nor are they so abundant upon a given area; but for all that, these ranges feed thousands of head of stock. Associated with these dominant species are five or six species of needle grass (*Aristida* spp.), two or three drop-seed grasses (*Sporobolus* spp.), several six weeks gramas and other annuals (*Bouteloua* spp., *Munroa squarrosa* (Nutt.) Torr.), vine mesquite grass (*Muhlenbergia Porteri* Scribn.), and several others. The ranges of this character suffer more quickly and more permanently from overstocking, because the better grasses are more easily killed out and are harder to replace.

The forested areas have the most diversified grass flora, but even here a few species are almost always prominent. Blue grama is nearly always present and usually dominant in the open parks and valleys of the forests below 8,000 feet. A prominent member of the society is the Colorado blue-stem (*Agropyron occidentale* Scribn.), and two other species of

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\*The buffalo grass occurs with this society in places in the southeastern part of the Territory.



this genus (*A. tenerum* Vasey and *A. pseudorepens* S. & S.), are common along little streams. The brome grasses (*Bromus* spp.),—the “wild oats” of the stockman—and the spear grasses (*Poa* spp.)—relatives of the Kentucky blue grass—, June grass (*Koeleria cristata* (L.) Pers.), the bulbous panic-grasses (*Panicum bulbosum* HBK. and *P. virgatum* L.), Eaton’s grass (*Eatonia pennsylvanica* (DC.) Gray), Arizona fescue (*Festuca arizonica* Vasey), and a number of others form a noticeable part of this society.

On the upper slopes of the high mountains above timber line or in the open “burns” often found at elevations of 8,500 or 9,000 feet, is another grass society whose dominant member is nearly always the Arizona fescue (*Festuca arizonica* Vasey). Associated with it are species of brome grass (*Bromus* spp.), the wheat grasses (*Agropyron* spp.), and a number of other grasses which grow luxuriantly only where it is cool and water is abundant. Such areas are about the only true summer ranges found in the Territory. They are accessible only to sheep and goats but are very valuable summer pasture for such stock.

Not infrequently in the mountainous regions there occur relatively small basin-like areas, into which considerable of the water of the surrounding slopes drains. Small marshy or swampy areas are thus formed (generally referred to by the Spanish word for marsh, *ciénega*, or some corruption of it), which are occupied by the various sedges (*Juncus* spp., *Carex* spp., *Eleocharis* spp., and *Cyperus* spp.), as well as several water-loving grasses, such as *Hordeum nodosum* L., *Agrostis exarata* Trin., *A. stolonifera* L., and the wheat grasses (*Agropyron* spp.). Generally such places are enclosed, partly drained, and the crop cut for hay.

The areas classified by Mr. Newell as woodlands are intermediate between the forested areas and the plains. They are normally rough ridges and mesas covered with a more or less scattering growth of low trees and shrubs, such as junipers, piñones, oaks, ash, hackberry, mountain mahogany, and

the like. The grasses common in such localities are mainly those of the plains, with a few others. Blue grama, hairy grama (*Bouteloua hirsuta* Lag.), side oats grama (*Antheropogon curtispendus* (Michx.) Fourn.), mutton grass (*Poa Fendleriana* (Steud.) Vasey.), several species of *Stipa*, and some few *Aristidae* go to make up the society.

The river valleys, where not in cultivation, are usually occupied by bunch grass\* (*Sporobolus airoides* Torr.), and, if moderately moist, by the true salt grass (*Distichlis spicata* (L.) Greene). Occasionally aparejo grass (*Muhlenbergia utilis* Torr.) occurs, forming, as does the salt grass, a tolerably thick sod in favorable localities. In certain places along these valleys the land is so low as to be kept saturated with water which may either come in as backwater from the river or come up from below. In such places the bunch grass is replaced by sedges and rushes. None of these grasses is a particularly valuable forage or pasture grass, but they are frequently fenced as pasture, for lack of anything better. Both the bunch grass and the salt grass have been reported as killing stock under certain conditions. Nevertheless some ranges contain little else over comparatively large areas.

Bunch grass and salt grass, a sedge (*Juncus mexicanus* Willd.), needle grass, and tobosa not infrequently occur on alkaline flats. With the possible exception of salt grass, none of these absolutely requires an excess of alkali in the soil in which it grows, but all of them will endure relatively large quantities of it. Hence while they are not necessarily indicative of alkali in the soil, they suggest the desirability of an examination for the quantity of those salts present.

Associated with such alkali flats in parts of the Territory are ridges and dunes of almost pure gypsum. A few grasses seem to be restricted to such locations, among which may be mentioned *Sporobolus Nealleyi* Vasey and *Bouteloua ramosa* Scribn. Bunch grass, indian millet (*Eriocoma cuspi-*

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\*Sometimes called salt grass and sometimes sacaton, neither of which is correct.

*data* Nutt.), *Muhlenbergia pungens* Thurb., and a drop seed grass (*S. cryptandrus* (Torr.) Gray) occur upon sand dunes whether they be gypsum or not, being associated in such localities with the grasses of the region in which the dunes occur.

Certain barren, rocky ridges have a grass society that is tolerably characteristic. The members are usually black grama, side oats grama, some needle grasses, some of the coarser blue - stems (*Andropogoneae*) *Pappophorum Wrightii* Wats., members of the genus *Tridens*, and *Lycurus phleoides* HBK. The relative numbers of each present would vary with every ridge examined.

#### Other Range Plants

Of the annual herbaceous plants which come each year at their appropriate seasons, those which appear early in the spring before the grasses have commenced to grow, are very important. There are many of these, but some of the early borages and plantains are probably most important because of their abundance and wide distribution. During the summer months the different pigweeds (*Amaranthus* spp.), the lamb's quarters, burro weed, greasewood, salt bushes, and other species of the Goosefoot family are of much importance on the drier and hotter plains, while in the forests and woodlands are species of clover (*Trifolium*), peas (*Lathyrus*), vetches (*Vicia*), lupines (*Lupinus*), beans (*Phaseolus*), and many more which form a very important part of the forage crop. A root-perennial, known to sheep herders as "estafiata" (*Artemisia frigida* Willd.), is a very important part of the early summer forage and saves many sheep in the lambing season whenever for any reason the grass is late in starting.

But the shrubby plants, whose leaves and young stems are eaten, are much more important, because this part of the crop can be depended upon each year whether there be the customary amount of rainfall or not. In practically all the mountains there occur species of oaks whose leaves are eaten

by all kinds of stock, and they form a very important part of the forage crop. A shrub common in the opener more barren mountains and in the arroyos leading from them is the Apache plume\* (*Fallugia paradoxa* (Don.) Endl.), which is browsed extensively. The mountain mahogany (*Cercocarpus* spp.) is another plant which is much used in the more barren mountains, along with a near relative, sometimes called "wild crape myrtle" (*Holodiscus australis* Heller. It has no affiliation and little resemblance to its namesake.) In the valleys and to some extent upon the mesas of the southern part of the Territory, mesquite (*Prosopis glandulosa* Torr.) is quite abundant and a very important addition to the early summer forage. The shadscale† (*Atriplex canescens* (Pursh) James) occurs widely scattered all over the Territory, and is eaten extensively, while on thousands of acres in the northern part there is a thick stand of one or more of the sage brushes (*Artemisia* spp.), which are highly valued by stockmen. In times of scarcity cattle will eat the leaves of the Spanish daggers (*Yucca* spp.), the bear grass (*Nolina* spp.), and even the spiny cacti. It is believed that the carrying capacity of our ranges may be much increased by growing cacti upon them and burning the spines so that stock can eat them. This has been profitably accomplished in a number of places and has been especially profitable when other feeds were scanty and stock too poor and weak to drive off the range. Under such conditions cacti will save the lives of many animals which would otherwise perish.

### Weeds and Poisonous Plants

Besides the plants which are valuable upon the range, there are a number of others which are more or less undesir-

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\*This is a common name originating with Mr. Jas. K. Metcalfe, who has studied the native forage plants of New Mexico for many years. It is particularly apropos, and since I can find no other name in use for this rather common plant I use it here.

†Th's is a near relative of the Australian salt bush. It is not infrequently called sage brush but is not closely related to the shrubs which bear that name.



Figure 8. Poppy-Thistle (*Argemone* sp.) Taking a Range.



Figure 4. Good Pasture in the Mesquero Indian Reservation. The Owners Were Paying One Dollar Per Head Per Year for the Cattle.

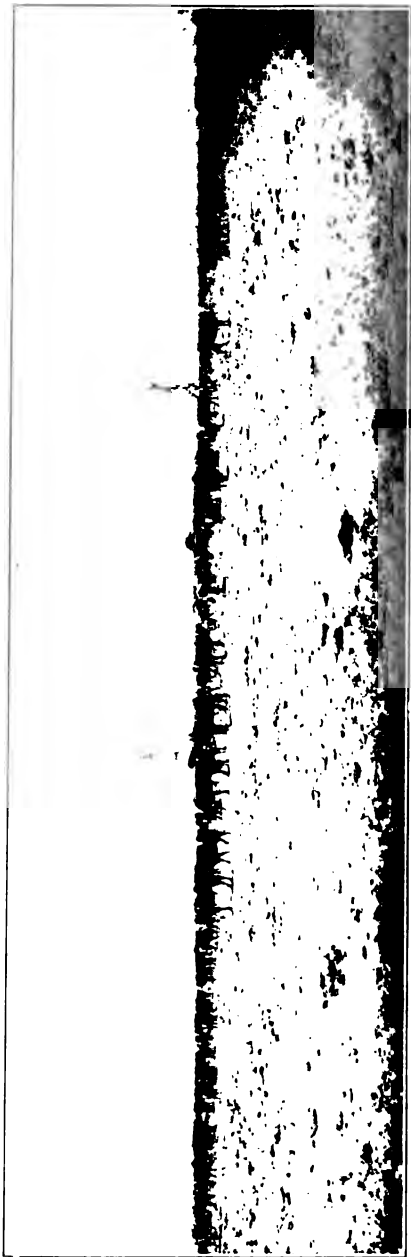


Figure 5. Cattle Near Watering Places. Note the Absence of Vegetation.



Figure 6. A Bare Spot. Not Uncommon in the Southern Part of the Territory.

able. Some of these are actually dangerous to stock; causing, as they do, considerable loss by poisoning, while others are undesirable only because they occupy land which might produce a forage crop, while they themselves are practically useless for any purpose whatever.

Of the poisonous plants a number are of considerable importance. The loco weeds (*Astragalus* spp. and *Aragallus* spp.) are probably of first importance as causing loss of stock. These plants are usually found in the foothills of the mountains or on the high plains at elevations of from 5,500 to 8,000 feet. Just what the poisons are has not yet been learned, and the only remedy yet found is to take the stock off the range and feed good nourishing food. Not infrequently it is cheaper to lose the stock than to feed. No steps have been taken to eradicate the loco weeds, as yet, though it is probable that in most places this might be done relatively easily.

In the higher mountains occur several species of Larkspur (*Delphinium* spp.), Lupine (*Lupinus* spp.), the Swamp Camas (*Zygadenus elegans* Pursh), and the Cowbane (*Cicuta occidentalis* Greene), all of which are responsible for the loss of stock each season. The Sleepy Grass (*Stipa Vaseyi* Scribn.), already referred to, is also a possible cause of loss. Some of these plants might be disposed of easily, but others would be more difficult to eradicate. The Rayless Goldenrod (*Isocoma heterophylla* (Gray) Greene), which grows in the lower valleys of the southern part of the Territory, has been reported as the cause of the death of range cattle and milch cows, and is believed to have caused the death of people who used the milk of the cows affected. This subject has not yet been thoroughly investigated, but will be in the near future. The trouble occurs only at a certain time of year after the plants have been frosted.

The possibility of weeds on the open range seems rather strange. If weeds could get a foothold, it would seem that they would ultimately take the whole range. But the grasses

are sufficiently assertive to maintain themselves against the inroads of nearly any other plants, unless their competitors are given some advantage. So it happens that in many places where the grasses and other valuable forage plants have been eaten and trampled out, other species, which live in such situations but which are not eaten by stock are thus relieved of competition and allowed to grow luxuriantly. Hence an area occupied by plants which stock will not eat, in a region where good forage plants should grow well, tells something of the past history of the area. Of the valueless plants thus occupying good land and telling of the past suffering of the range, several are quite characteristic. The prickly poppy or poppy thistle (*Argemone* spp) and the wild tobacco (*Nicotina attenuata* Torr.) not infrequently occupy large areas, from which everything else has been driven out; they particularly like open arroyos and draws, which have resulted from too rapid running off of the rains and melting snows. Two others of equal importance and frequency are the Rocky Mountain bee plant (*Cleome serrulata* Pursh) and *Croton texensis* (Klotzsch.) Muell. Perhaps the most important weed of this kind, which is taking thousands of acres of our higher plains, is what is known in various localities as sheep weed, snake weed, or *yerba del vibora*. It is a low, herbaceous perennial, which stays green nearly all year long. Its flowers are yellow, very small, and borne in small clusters at the ends of the very numerous, slender, resinous stems. Several species of the genus (*Gutierrezia*) have adapted themselves to the different climatic conditions of our Territory, where they are found in greater or less abundance on nearly all ranges. Lamb's quarters and pigweeds sometimes cover large areas, from which the grass has disappeared, but their presence is not altogether detrimental, for they are themselves eaten freely by stock. The Russian Thistle (*Salsola Tragus* L.) has been introduced practically all over the Territory and seems to be taking possession of some ranges where



the grass is badly killed out. Whether or not it will do more than this remains to be seen; it is now too late to hope to eradicate it, as might have been done years ago.

Certain areas of the Territory are occupied by plants which are valueless for forage. These plants can hardly be called weeds, for they are not displacing better plants, but their room might be occupied by others of value if these latter could once be introduced.

### The Condition of the Range

The author has had occasion to talk with many of the stockmen of the Territory and with a number of the "oldest inhabitants," relative to the character and condition of the particular range that each was conversant with. The almost invariable reply to questions as to the past condition of a range was a statement that much damage has been done to the range by overstocking. They all say that years ago the ground was level enough to drive over with a wagon where it is now almost impassable for a horseman. They also claim that certain areas were once cut over for hay, while there is now little or nothing on them, much less a hay crop.

The second report of the Public Lands Commission\* shows that of 118 stockmen of New Mexico reporting upon the ranges they know, 102 believed that the carrying capacity of these ranges had diminished while only 16 reported that their ranges had increased in carrying capacity. Of this number 69 believed the diminution was due to overstocking and 33 to drought. Since overstocking tends to produce drought this second answer may be at least merely another way of saying that overstocking probably produced most of the loss in carrying capacity.

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\*Senate Document 189 (1905), p. 7, and the reprint in *Forest Service Bulletin* 62, p. 13.

Attention has already been called to the value of range weeds as indicative of the degree and kind of overstocking to which a range has been subjected. Wherever the perennial grasses have been replaced by the annual six weeks grasses, a certain degree of overstocking is indicated. This is apt to occur within a mile or so of the watering places and shows the need of more watering places. Arroyos and washes occupied by poppy thistle and wild tobacco as well as flats covered by the bee plant show ranges badly overstocked by cattle. The arroyos show where trails have been and where not only the grass but even the soil is gone as the result of the overstocking. Level areas with much of the *Gutierrezia* on it show some degree of the extinction of the grasses due to overstocking by sheep. Thus it is possible by looking at a range to tell how it has been treated. The number and kinds of range weeds, the kinds and abundance of grasses, the condition of the shrubbery, the amount and character of the erosion features, all taken together with an appreciation of the common or typical condition of the locality in question, tell the story of what the range has been, and hence what it may be again by proper treatment.

### Why the Effects of Overstocking Are Cumulative

Stock of all sorts eat the kind of forage they like best *first*. Such forage is perforce the most valuable upon a range. If so much stock has access to it that the growth of each season is all eaten before it can seed, the best forage is bound to diminish in quantity every season, for some of it is continually being killed under even the most careful management. Thus it will be seen that, from this reason alone, the carrying capacity of a range is gradually reduced.

Plants maintain their relations to each other, in any plant society, in the same way that animals do. Those plants best fitted to live in a given region become the dominant species

by crowding the weaker species out. But the introduction of a new enemy to the dominant species may make it possible for another species of much less vigor to become the dominant one merely because its more powerful enemy has been displaced and itself allowed to grow and reproduce. Thus it always happens that a range which is overstocked, first loses its most valuable grasses, and the range becomes poorer; and finally, if the overstocking continues, everything which the stock will eat is destroyed and only those plants which they will not touch remain.

The effects of overstocking are to be seen around most of the watering places, because stock go just as short a distance away from water as will supply them with food sufficient to appease their hunger. Where watering places are but short distances apart the country around them is not "skinned" so closely of its vegetation. The perfectly bare condition of the land surrounding the watering places is undesirable for two other reasons. It becomes packed hard by the trampling of many feet; and, radiating from the troughs, are scores of well marked paths which become little gutters to carry off the water which falls upon the packed and unprotected land. Thus other effects of overstocking are to make the land so that it will not absorb the water that falls; to hasten the run-off of the water and give it little opportunity to soak in; to use the force of this run-off to carry away the loose and lighter parts of the soil, thus rendering the region less able to grow forage; and at the same time to render the surface more uneven and better fitted for occupancy by range weeds. The careful observer is able to tell pretty accurately the treatment the range has received by simply riding over it and seeing the kinds of plants present, the relative abundance of each, the condition of the trails and roads, and the number and size of rocky or gravelly arroyos. Each tells its own story of too much stock.

We have all become more or less familiar, largely

through the efforts of the Bureau of Forestry, with the effects of removing the forests from a region, and vigorous efforts are being made, especially in the arid districts, to protect such regions from the effects of deforestation. Little attention has as yet been paid to the effects of overstocking upon the run-off of flood waters, though examples of it are common in our Territory. A particular instance, the history of which is known to the writer, will illustrate the point.

The Mangas Valley is a narrow valley about 35 miles long, heading in the Burro Mountains, 15 miles southwest of Silver City, and running nearly north through a hilly country to the Gila. Until four years ago there were, about half way down the valley, a number of springs (Mangas Springs), which formed a marsh of several acres and supplied a little stream probably not over two feet wide, which ran down the valley. Years ago two or three settlers homesteaded claims below the springs and used the water of the little stream for irrigating their farms. They brought in some stock, and later large numbers of cattle were run in the valley and on the hills which drain into it. Wells were driven at several places above the springs, and, since the grass was abundant and of the best, the cattle lived mainly in the valley and on the nearby hills. Shortly thereafter the run-off of the summer rains began to come down as floods, small at first, but getting larger and larger as the seasons passed, and more grass disappeared. The floods commenced to cut out a deep channel, through which their waters were carried to the Gila. In fifteen years these floods, coming probably not oftener than one or two a year at first, cut out a channel about three-fourths of a mile long, 75 feet wide, and 18 to 20 feet deep, which completely drained the swamp and put the water at such a level and diminished its quantity so much that the little farms are ruined. The owner of the springs assured me that such a thing as a flood was not known at his ranch until after stock had been on the range for years, but

that now larger or smaller ones come down within an hour or so after it commences to rain. Figure 12 shows what was cut out in one night as the result of a tolerably severe thunderstorm, lasting about two hours, over the head of the valley. The hills to the west and mountains at the head of the valley are covered with scrubby timber, but little or none of it has been cut off. The erosion here referred to is the result of overstocking and nothing else, and shows very conclusively how the removal of the grass and other small herbage will cause the run-off of a region to change from a gentle seeping into and through the soil to a surface flow, which becomes in the end rapid, violent and destructive, and even dangerous to life.\*

The rapid run-off of the waters when they fall, or of melting snow causes the permanent water in springs and streams to gradually diminish in quantity and in many cases ultimately disappear. Thus the watering places, upon which the whole grazing industry depends, are destroyed.

### The Carrying Capacity

The approximate grazing area is known as well as the total number of stock now on the ranges. From these data it is possible to obtain the average carrying capacity under the present form of management. The following table gives the number of cattle, horses and sheep reported on the ranges of the Territory for a number of years.

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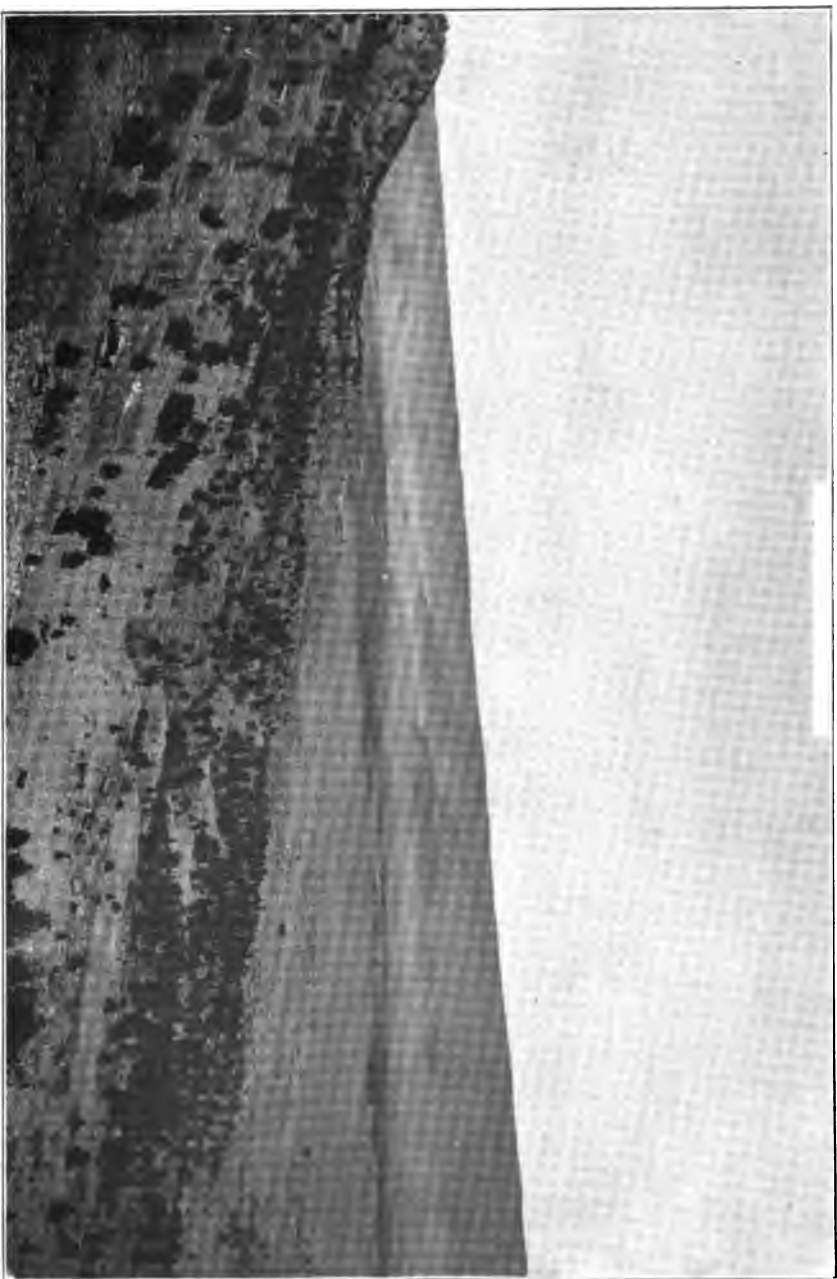
\*One or two persons have been drowned at the Mangas crossing in summer floods.

| Year    | CATTLE         |                        | SHEEP          |                        | HORSES         |                        |
|---------|----------------|------------------------|----------------|------------------------|----------------|------------------------|
|         | Number of Head | Average Price per Head | Number of Head | Average Price per Head | Number of Head | Average Price per Head |
| 1880    | 137,314        | .....                  | 2,088,831      | .....                  | 14,547         | .....                  |
| 1882    | 375,000        | \$19.26                | 3,960,000      | \$1.50                 | 16,640         | \$42.92                |
| 1883    | 690,562        | 20.01                  | 4,435,200      | 1.70                   | 17,139         | 43.50                  |
| 1884    | 959,881        | 18.83                  | 5,410,944      | 1.64                   | 17,996         | 37.69                  |
| 1885    | 1,151,857      | 18.00                  | 4,328,755      | 1.60                   | 19,796         | 39.37                  |
| 1888    | 1,257,597      | 15.04                  | 3,623,168      | 1.09                   | 40,533         | 34.46                  |
| 1889    | 1,383,357      | 13.48                  | 3,516,473      | 1.14                   | 42,560         | 33.52                  |
| 1890    | 1,383,357      | 11.25                  | 3,097,736      | 1.25                   | 52,350         | 29.66                  |
| 1891    | 1,341,856      | 11.01                  | 3,123,063      | 1.69                   | 33,504         | 31.02                  |
| 1892    | 1,288,182      | 11.01                  | 2,967,480      | 1.54                   | 93,000         | 29.09                  |
| 1893    | 1,249,537      | 10.03                  | 2,730,082      | 1.50                   | 91,140         | 23.31                  |
| 1894    | 1,224,546      | 9.44                   | 2,921,188      | .....                  | 92,963         | 15.80                  |
| 1895    | 979,637        | 7.49                   | 3,008,824      | .90                    | 86,456         | 15.37                  |
| 1897    | 753,831        | 11.76                  | 2,683,269      | 1.06                   | 84,701         | 14.65                  |
| 1898    | 731,216        | 16.06                  | 2,844,265      | 1.89                   | 83,854         | 18.18                  |
| 1899    | 659,849        | 18.64                  | 3,973,439      | 2.17                   | 83,184         | 20.21                  |
| 1900    | 996,990        | .....                  | .....          | .....                  | .....          | .....                  |
| 1901    | .....          | .....                  | 3,360,000      | .....                  | .....          | .....                  |
| 1902    | 872,471        | 17.45                  | 5,677,156      | 1.72                   | 118,298        | 22.69                  |
| 1903    | 916,095        | 14.55                  | 3,860,466      | 1.93                   | 115,932        | 17.52                  |
| 1904    | 851,968        | 13.84                  | 2,856,745      | 1.98                   | 112,454        | 22.68                  |
| 1905    | 903,086        | 14.84                  | 3,999,443      | 3.15                   | 113,579        | 30.29                  |
| 1906    | 948,240        | 17.00                  | 4,558,365      | 2.95                   | 119,258        | 42.00                  |
| Average | 1,027,205*     | \$14.20                | 3,956,586      | \$1.70                 |                |                        |

\*Omitting first two records, when the ranges were just being stocked.

The table is as complete as it was possible to make it with the facilities at command and is sufficiently extensive to be valuable for present purposes. It is compiled from the annual reports of the Secretary of Agriculture, the Yearbook of the U. S. Department of Agriculture, and the reports of the Governor of New Mexico.

Custom varies considerably in the matter of the number of sheep or goats which may be taken to be equivalent to one cow when considering the acreage necessary for each per year. Prevailing usage in New Mexico seems to be to figure four sheep as the equal of one cow in their effect upon the range. In other places five or even six head of sheep are considered as equal to one cow. Horses are generally considered as equal to cows, and goats to sheep in such estimates. The statistics given in the table relative to horses are not so arranged as to show the number of head which run on the ranges; all kinds of horses are included. It is probably fair



**Figure 7. Range Conditions in the Northeastern Part of the Territory. Photographed by Dr. David Griffiths.**



**Figure 8. Mangas Valley, Near Mangas Springs. Cut Out in One Night as Result of An Ordinary Rain of About Two Hours' Duration.**



to estimate the range horses of the Territory at about 50,000 head. It has been impossible to get data as to the number of goats running upon our ranges, but there are no doubt several thousand head.

Taking (1) the average number of head of cattle, 1,027,205; (2) the cattle equivalent of the average number of head of sheep, 899,146; (3) assuming the number of range horses to be 50,000, and (4) the number of goats at about 100,000, the cattle equivalent of which would be 25,000 head, we have the equivalent of a little more than 2,000,000 head of cattle as the average number supported by the ranges of New Mexico all the time. Taking 90 per cent of the territorial area as representing the total grazing area now in use we have 67,650,000 acres on which are supported 2,000,000 head of cattle, or an average carrying capacity of 33.8 acres per head per year. Just how the figures relating to sheep and cattle are obtained is uncertain, but they are probably taken from the tax assessment returns, at least in part. If this is the case, there is little doubt that the numbers are too small. Assessors and collectors have said more than once to the author that the tax returns generally show less than the actual number of stock and frequently very much less. In one case that the author remembers, it was a local joke that one season a large company shipped more stock than it paid taxes on, and it wasn't selling out either. A pronounced increase of the figure representing the total number of stock would raise the carrying capacity materially.

As a matter of fact the carrying capacity of our ranges is very different for different localities, and changes in the same locality with the seasons. Speaking very generally, the ranges of the south central and southwestern part of the Territory have the lowest carrying capacity, though the northwest corner is also low. A fair estimate for the southwestern part (and one made independently by two experienced managers of large cattle interests of the region), tak-

ing the plains and mountains together as they occur, is 40 acres per head\* per year, or 16 head per section. The whole south central portion taken as a whole is not even as good as this. Probably 50 acres to the head is as much as it can carry. This is due to the fact that much of this area has little or no forage on it at all. Thousands of acres have little vegetation on them except creosote bush (*Covillea tridentata*), *Flourensia cernua*, *Acacia constricta*, etc., none of which stock eat. Hence areas that stock do run upon have a carrying capacity higher than that given. The average carrying capacity is still further diminished by the absence in some well-grassed regions, of sufficient water to render the forage available. This condition may be changed by developing water.

The southeastern part of the Territory, including the Sacramento and Guadalupe mountains, their eastern slopes, the plains through which the Pecos flows, and the "staked plains" further east probably have an average carrying capacity not far from 25 to 30 acres per head. Much of the mountain region has a higher capacity than this, but in the higher parts of the mountains stock move out in the winter time, thus reducing the actual carrying capacity considerably. The forage is there but it is not utilized since much of it is good and palatable only during the summer when it is green, and portions of the high mountain ranges are snow-covered and uncomfortably cold during much of the winter. Neither of these conditions obtains on the open plains to any extent; though cold and snow both occur, they are rarely of long duration.

The carrying capacity of the large basin lying between the Mogollon Mountains and the Black Range and including the eastern and western slopes of these mountain ranges respectively, has been estimated at an average of 30 acres per head, but this might be materially improved by control. Some

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\*Estimates in terms of cattle.

of this region is probably capable of being cultivated by dry farming methods, and feed so produced could be used for winter feeding, thus making possible a more complete utilization of the summer forage. The region west of the Mogollon range has been estimated at 60 acres per head, but the author believes this is an underestimate, and would really apply to but a small part of it. The land is very broken and has been badly overstocked for several years, but the carrying capacity is more like 40 acres per head, and could be increased to 25 acres per head without much difficulty under proper management. Cattle and sheep wars have been fought over this region and, while some stock have been crowded out and some have been voluntarily moved out, the range has suffered seriously in the conflict.

Regions like the San Augustine Plains, the plains of the Puerco and San José, the Estancia plains, and those east of the Pecos and north of Roswell for 100 miles or more, have normally a high average carrying capacity, probably from 20 to 25 acres per head or 25 to 30 head per section. These regions have been occupied mainly by sheep for a long time and largely through carelessness and laziness of herders the ranges have been overstocked. They are eroded very little, but are very weedy, the "sheepweed" (*Gutierrezia* spp.), being very common in these regions and in some places almost replacing the original blue grama grass (*Bouteloua oligostachya*). The mountains which surround these plains and separate them from each other are inferior in carrying capacity only on account of their winter climate. They probably have an average carrying capacity of not less than 30 acres per head.

Overstocking with sheep is particularly exasperating, because it is so unnecessary, and is chargeable generally to pure laziness on the part of the herders. The sheep are held too long in one place—so long that they kill everything which they can eat. Then when they move on there is nothing left to grow but the undesirable plants of the region. This may

not be and usually is not done all at once, but the habit of staying too long in one place, if persisted in, will ruin the best range, even if it has more than sufficient capacity to carry the stock upon it. A range so treated cannot recover when the stock are moved, because there is nothing but weeds left to recover, and once they are given possession the valuable plants are crowded out.

The high plains and mountains south of the Santa Fe Railroad, west of Grant, constitute an area of relatively large carrying capacity, certainly not less than 20 to 25 acres per head, and the mountains and high plains of the north central and northeastern part of the Territory are fully as good or better. It is possible that these regions may be much improved by dry farming methods. That part of the Territory lying northwest of Grant between the Santa Fe Railroad and the Colorado and Arizona borders is a region of rather poor carrying capacity, and has been badly overstocked by sheep for years. It is now able to carry not more than about 16 head to the section, or an average capacity of about 40 acres per head.

In the opinion of the author there is hardly an acre of range land in the Territory the carrying capacity of which may not be improved by a very small amount of effort and the use of ordinary judgment. Such improvement will amount to from 20 per cent to over 100 per cent on nearly any of the ranges; those which are now in the worst relative condition, will, of course, respond with comparatively the greatest gains. There is but one way in which this desirable result may be obtained. Men will make the necessary effort to improve and protect the range only when they are absolutely guaranteed that whatever of benefit may come as the result of their efforts shall become their own gain. The whole matter may be summed up in the one expression, individual control and individual responsibility.

An increase of 20 per cent in carrying capacity *such as has been obtained by control and good management*, if obtained all

over the Territory, would have a pronounced effect upon every industry. And such an increase is entirely possible if stockmen are given control of their ranges and required to take care of them or turn them over to someone who will.

### The Financial Value of the Range

What is the actual value which the stockman gets from each acre of his range each year? Of course, this is the difference between total expenses and gross receipts. If the figures assumed in another place be used, we have the problem stated thus: If 40 acres be sufficient to carry one cow, and the rate of increase be 50 per cent, and the yearling be sold at \$15, what has the stockman gotten from the 40 acres? The gross receipts are \$7.50 for the 40 acres, but from this must be deducted the interest on the proportional part of all money invested in the cow, fences, pumps, troughs, corrals, buildings, etc., the cost of all service necessary in caring for the cow and yearling, and all other running expenses. It thus becomes evident that the rental value of such land per acre is not very large. But any increase in carrying capacity makes a corresponding increase of income per acre of land.

Much of the land belonging to the Territory and managed by the Territorial Land Commissioner is now rented for grazing purposes. The prices charged are not less than two or three cents\* per acre for lands without water and five cents per acre for lands with sufficient water for stock: rental for one year payable in cash in advance, balance by properly secured notes. On land having a carrying capacity of 40 acres per head of cattle per year, the Territory is now charging from 80c to \$1.20 or over per year per head for land without water and \$2.00 or more for land with stock

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\*Minimum rental depends upon whether the land is public school land (sections 16 and 36 in each township) or lands belonging to other Territorial institutions.

water.\* It is likely that some of the land having water upon it is rented at such a price because it controls the public land surrounding it. There is no doubt, however, that for much of such land as this, the carrying capacity is greater than the above estimate and hence the cost per head is less.

Agents on some of the Indian reservations have given grazing permits to stockmen who have stock in the region. In one case the rental charged was \$1.00 per head for yearlings and older cattle per year. Both parties were satisfied with such an arrangement and it is likely that this is near what the business can carry. Any rental based upon the acreage of land must take into consideration the carrying capacity, while a rental per head must also assume it. In the one case the stockman must know the carrying capacity in order that he may estimate the annual cost of pasture per head. In the other the renter must know something of the capacity or he may get his range overstocked or not get as much for his pasture as he might in perfect safety.

The fees charged for the use of the pasture upon the national forest reserves are shown in the "Use Book"\*\* for 1907. They range from 20c to 35c per head for the summer season, for horses and cattle, to 35c to 60c for the entire year; and from 5c to 8c per head for sheep for the summer season to 10c to 18c for the year, with a charge of 2c extra per head for the privilege of lambing in the reserve. Goats are charged a little more than sheep. All stock over six months old is charged for pasture. Having no information as to the carrying capacity used in making charges in the forest reserves, it is not possible to determine what the equivalent rate per acre is. From this it may be seen that there is no attempt to charge more for the use of the pasture in the national forest reserves than a nominal fee which is used for maintaining the full effectiveness of the reserves

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\*Land with water sufficient for irrigation is classed as agricultural land and rents for more.

\*\*Page 104.

in all particulars and in a condition of legitimate use. The fee is considerably less than actual value received as well as less than what men have shown themselves willing to pay private parties for similar privileges.

The minimum rental for grazing lands in Texas is 3c per acre.\* The usual rental charged for grazing lands without stock water in Wyoming is 2½c per acre.\* Whatever fee might be charged for the public range it would be such as would result in placing the public property in the hands of responsible parties who would appreciate the value of the trust and would be willing to make reasonable efforts to maintain the pasture in its best state.

### The Method of Management

It has been the author's privilege to travel over a relatively large part of the Territory in a wagon and make definite examination of the condition of the range. Almost without exception, wherever he has gone, he has seen the evidences of bad management. The practically uniform policy of the men getting the benefit of the range has been to get all they could in the shortest possible time without the least consideration for the range.

This method of management is explainable in one way only. The open range is public property, and being a gift to no one in particular, and every citizen having a right to use it, he who takes all he can and takes it most quickly, gets most of it. Since this gift is valuable, there is considerable competition to get it and there is no longer enough to "go around" among those who wish to take it. The result of this struggle for the "eggs" of the "goose that laid the golden egg" is a marked decrease in the "egg" supply and sad inroads upon the physical vigor of the "goose."

The stockman cannot even protect the range from him-

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\*Forest Service Bull. 62, p. 49 and p. 56.

self, because any improvement of his range is only an inducement for some one else to bring stock in upon it, and he thinks he had better put the extra stock on himself. Hence stockmen run all the stock on a given range which it will possibly carry at the time, with little thought for their own future and practically none for the future of the range. There is no one authorized to take care of the public range, and the present form of management has tended to make the beneficiary careless of the source from which he gets his livelihood, merely because he does not have legal control of the range he uses.

The lack of legal control acts detrimentally upon the range in two ways. Those men who, for their own benefit or from more altruistic motives, might care for and improve the range they are using, dare not do so for fear that their labors may only bring them competitors; hence there is no inducement for the desirable kind of an occupant to do what he otherwise would do gladly. For those individuals who are carelessly or consciously ruining the ranges there is no possibility of censure, much less of punishment, since they have no definite legal authority and consequently no definite responsibility.

Such a plan of management, or more properly speaking, such an absolute lack of plan or proper management, could produce little but poor results. The very greed of the users of the range and the periodic occurrence of dry seasons have been the only form of protection the ranges have had. The former causes overstocking and almost complete destruction of the forage crops. Then a dry season comes and the stock must be taken off the range or they will die off. Usually a large part does die and while the stockman is recovering from the financial loss and getting the range restocked, the range is itself recovering to some extent from the effects of the previous overstocking. And this cycle of changes is continually kept up, but each round of change





**Figure 9. A Bird's-Eye View Showing a Region Covered with Creosote Bush, *Artemisia*, etc.  
Carrying Capacity Very Low Organ Mountains.**



**Figure 10. Rough Country on the West Side of the Mogollon Mountains.**

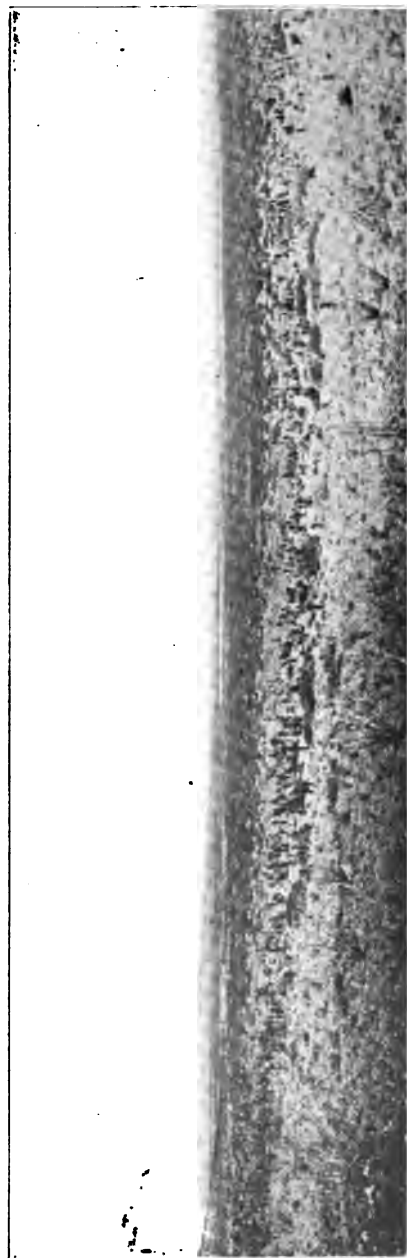


Figure 11. Black Grama, Tobosa, *Yucca radicans*, Mesquite. Southwest of Hachita.



Figure 12. Typical Black Grama Society. Near Tularosa.

leaves an ever increasing permanent impairment of the range behind it.

### The Desirability of a Better System of Control

There can be but one conclusion to be drawn from these conditions. Every interest at stake—the stockman's interests, the best interests of the range, and the interests of the general public demand that the range be given into the control of such citizens as desire to use it and use it properly, and who may be given definite legal rights with respect to it and held personally responsible for the proper use and care of what is really public property. An *ideal* division of this public domain would place it in the hands of as many individuals living upon it as it is capable of supporting; but the existing land laws are of such a character that one may not acquire title to a sufficient quantity of this land to make a living upon, and control by title is the only form of control now possible. The land is good only for grazing and its carrying capacity is so small that from 2,500 to 7,500 acres of land (4-12 sections) would be necessary to support a family expending \$1,000 a year, assuming cattle worth \$15 per head and that the normal increase of such stock would be 50 per cent (carrying capacity 20-60 acres per head). These assumed values are a little low for normal years, but probably not far from the average. Non-resident or corporation control is not ideal but is much better than the present method of management, because the right to control brings responsibility with it, and, what is even more important, it renders careful management profitable to the parties in control.

### The Results of Control

The most important result of granting control to the user of a range is that he is then able to plan for a definite length of time in the future. He is able to ask himself how he had better conduct his business so that he may get better returns

from his holdings. The provident stockman will at once recognize the limitations of his range and instead of being forced to put on all the stock it will temporarily carry, he will put on less than it can carry, even for an extended period. He will immediately fence his range so he may know just how many head he has on a given area and will thus get accurate data as to carrying capacity where now he has only a hazy estimate or absolute ignorance. It will be to his interest to develop water at frequent intervals so that stock need not travel far for feed, thus distributing his stock more evenly over the grazing area. The ability to fence makes it possible not only to shut out the stock of a careless or overreaching neighbor, but also allows him to keep his own stock off a pasture which needs rest. It is then possible for him to use one pasture for the summer and save certain others for winter feed. It is possible for him to guard against the evil effects of poisonous plants, which are usually not abundant and occur only in restricted localities. Having control means that, if he is provident, he will kill out poisonous plants and bad weeds; he will stop arroyos and let them fill up and become set with grass. A very little work of this kind judiciously done will add many acres of grass land which are now nothing but rocky and gravelly weed beds. Definite efforts at re-seeding badly worn parts of the range are known to be a profitable investment of time, money, and effort. In a word, legalized control changes a "range" into a set of "pastures," and the presence of the fence eliminates a very large proportion of the uncertainty of the business. As an illustration of the truth of these statements, at least in part, I quote at length from a report and a letter relative to some considerable holdings in the southeastern part of the Territory.

The property is that of Mr. J. J. Hagerman and lies not far from Roswell. Shortly after it was fenced Mr. Hagerman had it carefully examined by Dr. David Griffiths, of the United States Department of Agriculture. Dr. Griffiths is an experienced investigator and is acquainted with the

ranges of much of the western United States, hence his judgment is of value. The following is quoted from his report of the examination made in 1903. After discussing the general character of the soil and the grasses, he says:

"There is so little data regarding the carrying capacity of native pastures that it is a very difficult matter to make an accurate estimate, especially when one is obliged to judge upon pastures which have been much abused in recent years, coupled with the variability of the seasons in this locality. Mr. Hinkle and myself, after riding over the ranch in May, agreed that one head to 22½ acres, or 10,000 on the entire ranch, would be a conservative estimate of its carrying capacity; and subsequently I discovered while in conversation with Mr. Hagerman that he had previously decided on about the same thing. He had estimated that he could hold 8,000 cows. These two estimates are practically the same, when one makes provision in the latter for the calves and bulls for a period of about six months of each year. I believe that this estimate is conservative, and that with a proper distribution of water the pastures can be kept in good condition indefinitely. The past season has been an unusually dry one, and the crucial test will come during the present winter."

The following letter, written in 1906, in answer to my inquiries as to the results of their treatment of the range, explains itself:

"Dear Sir—\* \* \* \* We fenced most of the Arroyo ranch, 240,000 acres, late in the fall of 1902, some of it not until early in 1903. When fenced it was divided into eight pastures, enabling us to give various parts of it a long rest, which we have done, and the result is extremely satisfactory. We began with about 5,000 cows and enough bulls to make one for about every eighteen cows. It was, as you will see, very much understocked.\* During 1904 and 1905 the rainfall was abundant, and it has been fairly good during this year.

"On large areas, which in the fall of 1902 and during 1903 seemed very discouraging, the grass now is splendid. This is particularly the case in one field of 60,000 acres which had been much over-grazed with sheep, and which we gave a complete rest during all of last year. There is a good deal of grama grass on this and it is now knee high and close together. The other grasses seem to have improved equally well. We now have 10,000 head of grown cattle and about 4,500 calves. We have about 50,000 acres which we have not used this year but will use during the winter.

"Our experience makes us believe that, taking one season with another for a long period of time, we can carry one grown animal (ones and over) on every eighteen acres without overstocking it. I mean exclusive of the calves. It will take more time to fully con-

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\*45 acres per head.

firm this opinion, but we believe it to be true. This year we have about 4,500 calves, being about 78 per cent of the cows bred or supposed to have been. When we put down more wells and otherwise improve our water supply we think this record can be beaten. We hope to get the tract so well supplied that an animal will not have to travel more than three miles to get water.

"We have attempted nothing in the way of range improvements, excepting to keep the cattle off over-pastured grass and give nature a chance to do its work. Of course, the public range outside our fence has been used and abused just as it always has been before we fenced our land. The contrast between the two is startling, and would be a good object lesson to those who object to the government taking care of a public domain, if their minds are not closed by selfishness. In my opinion, if the public domain is not taken care of, the time is not far distant when it will be ruined for grazing purposes.

(Signed) J. J. HAGERMAN."

This is a single case, but the business has been carried on on such a large scale that it is fairly typical. The region referred to is of good natural carrying capacity for the Territory, but the three years' experience has shown that an increase of about 20 per cent has already been obtained, and that, too, merely as the result of giving the range rest. Much better results are no doubt possible when more active measures for the improvement of the ranges have been applied.

### The Remedy Proposed

We have seen that the present method of handling our ranges is wasteful and careless, and tends to the ultimate destruction of the stockraising industry. We have seen that every other industry of the Territory is directly or indirectly interested in the welfare of the stockraising industry and hence is harmed by such a method of handling the ranges. We have seen that the essential feature of this method of management which makes it bad instead of good is the lack of some definite form of control of the ranges placed in the hands of responsible citizens. The reason for this is that the land laws were made to fit a humid agricultural region; and hence do not work well when applied to a dry grazing region, which will not support a dense population. It is not

deemed wise (and experience has confirmed the opinion) to materially change the homestead laws; because we do not know what new method of farming may be developed, which will render it possible for a man to make a home on 160 acres of such land as is still open to entry.

Various attempts have been made to frame a lease law which would supply the need, but such laws have always been unsatisfactory because they did not adequately cover the very diverse conditions obtaining in different parts of the public domain. Any sort of lease law was believed to be not sufficiently flexible to fit all cases and at the same time prevent possible improper use of the privileges granted. Thus it will be seen that the power to delegate individual control to larger or smaller bodies of land must be placed in the hands of some authority wise enough to understand the conditions of a particular locality and just enough to all to allow of no favoritism; an authority so far removed from personal interest in the particular case as to be able to adjudicate it for the best interests of all parties in any way concerned. In the opinion of many, such an authority is easily found in the proper official of the central government at Washington.

"The only practical remedy is to give control of the range to the federal government. Such control would not only stop conflict, but would conserve the forage without stopping its use, as our experience with the national forests has fully proved. It would likewise secure to the west the great benefits of legitimate fencing without interfering in the slightest with the settlement of the country—on the contrary, while promoting the settlement of the country," says President Roosevelt. The President's recommendation as to a method of control is as definite and clear as his appreciation of the need of control. He proposes that the work of managing this area of something like 400,000,000 acres be placed in the hands of the Secretary of Agriculture, who shall be required to administer it in the way to subserve the best interests of the people who are most vitally concerned, i. e. those now oc-

cupying and using the public range in the vicinity of their own homes.

Such a plan avoids the difficulties in the way of a lease law, since it thus becomes possible to adopt that plan of management which will apply to a given region and still prevent the same plan being applied to conditions which it does not fit. It also gives discretionary powers to the Secretary, by which the actual resident of a region may be given preference over the non-resident stockman. This is as it should be, for the man who is settled in a region which he has selected for his home is the man who should be permitted to run his stock on the surrounding public range. Such a man is more directly concerned with the control of that range than anyone else; and he would be more apt to give it proper care, because his own interests are closely associated with its permanent improvement. It also agrees with the governmental policy of favoring the homemaker wherever he may be found. But men so favored should pay the necessary managerial expenses caused by such a policy; and most stockmen are ready to pay the nominal grazing fees which are sufficient to cover these expenses. That the proposition is too big for the managerial ability of a member of the cabinet seems to the author a trifle absurd. It seems strange, however, that men can handle fully as large propositions as matters of private business.

Objections were offered to the proposed plan of control by a number of speakers at the Denver Public Lands Convention, the most consistent of which were: (1) That such a form of control made the central government a landlord dispensing lands to the people, thus making all the dangers of favoritism possible; while at the same time entering into the business of managing the public property for the profit of the general government; and (2) The extreme difficulty of the task on account of the large amount of land to be managed.

What is the attitude of the general government toward the citizens? Isn't the worst that can be said of it "benevolent



paternalism?" Did the United States government ever exploit the citizens of any region for the benefit of the central government? Isn't the ordinary case just the exact reverse? Does the governmental management of the postal service result in great revenue to the government or does it result in very cheap and efficient service to the people? Isn't the government committed to the policy of homemaking? And will not the establishment of a policy permitting the fencing of the public grazing lands under proper control increase the value of the lands of the resident land owner? And will not the assurance that one may have control of adjacent public range be an inducement to enter land, which is of itself insufficient to support a family? There is no intention whatever of withdrawing the public grazing lands from entry. The whole purpose of the plan proposed is merely the preservation of a goodly part of the "material basis" of our civilization elsewhere referred to.

What are some of the main features of such a system? What must the regulations provide for?

1. A responsible official in charge. He should be an officer of the general government, because the lands belong to the whole people, and because such an officer would be farthest removed from state politics. Preferably he should be a member of the cabinet.

2. The careful classification of the lands, with definite information as to carrying capacity of the ranges, the character of the forage, and climatic and other conditions likely to affect their value. Particular care should be taken to safeguard the mineral rights. Reclassifications should occur at stated intervals, and, for special reasons, at the option of the head official of the service.

3. The method of selecting lessees should be such as to favor the small owner who is a bona fide resident in the immediate vicinity of the leasehold. The method of selection, among individuals of equal rights in the respect of residence, should, where possible, be by lot.

4. The period for which the lease or permit shall run should be as long as possible, and the tenure be as secure as it can be made under the system. The holder of an expired lease or permit should have preference in re-leasing.

5. The quantity of land leased to one individual should be in direct relation to the number and kind of stock which he will put upon the range and the carrying capacity of the range. This latter factor must be very carefully attended to, because the whole plan is based upon the one idea of making the public grazing lands more productive.

6. The tenant should own certain kinds of improvements made by himself and have right to all water developed by himself upon the land. These improvements might be purchased by the general government on surrender of the lease, or transferred by the owner to any succeeding lessee.

7. Roads should be established, and right to travel over large tracts should be given under certain restrictions as to the rate of travel and area of land passed over.

8. The right to cancel leases or permits, for failure to fulfill requirements or for any good and sufficient reason should be vested in the chief officer or his delegate of a specified rank.

9. The grazing lands should not be withdrawn from entry; but the lessee should be guarded from the entrance upon his leasehold of any but bona fide homesteaders. The homesteading of land in a leasehold should carry with it a right to lease a certain maximum number of acres, provided this did not reduce the large leasehold below a certain minimum, which minimum should in no case be less than the maximum allowed the second lessee. In determining these areas the factor of carrying capacity must of necessity be taken into consideration.

10. The total rentals charged should be no more than sufficient to maintain the service and should be apportioned



Figure 13. Sheep in An Open "Park." Jewett Gap. Blue Grama Society with Some Arizona Fescue.

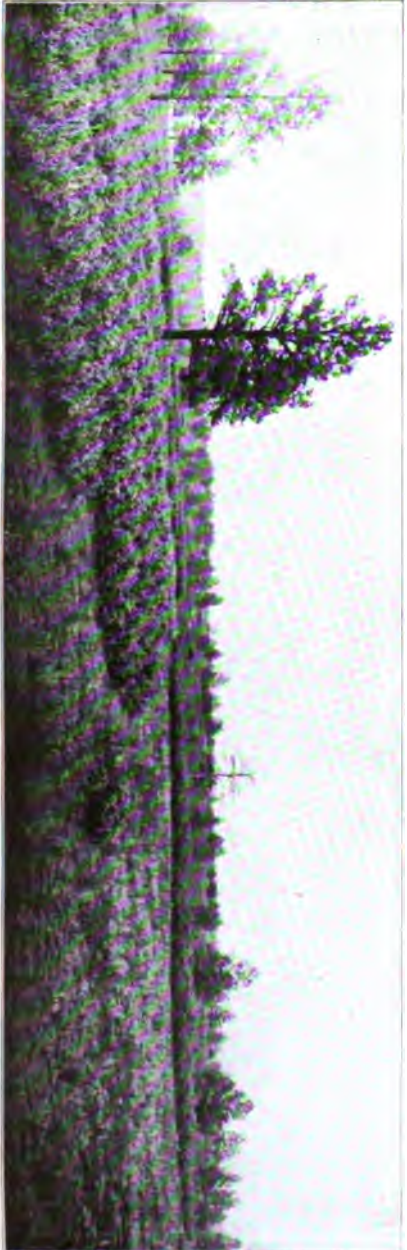


Figure 14. Oak Bushes, Browsed by Cattle. White Mountains, Near Aljo.

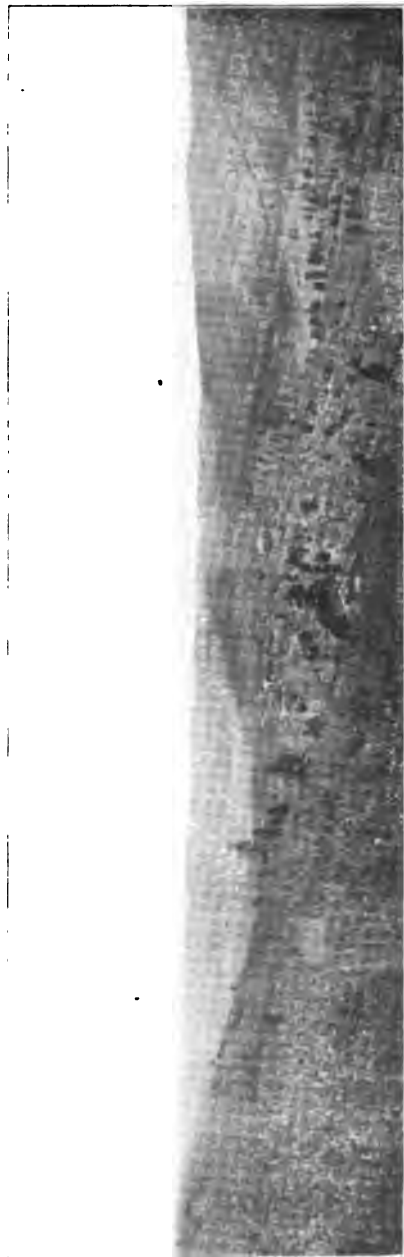


Figure 15. Forest and Woodland Conditions. Note Open "Park," with Blue Grama Society.

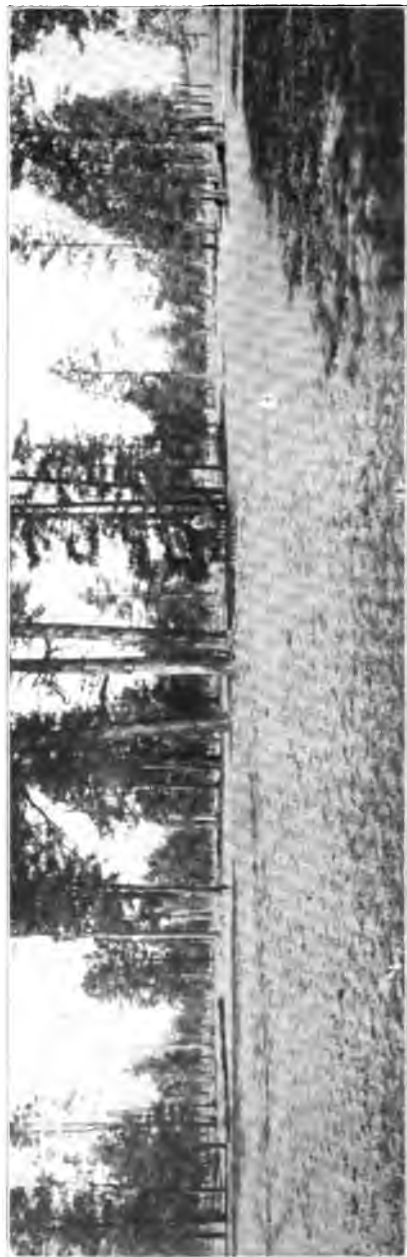


Figure 16. Blue Grama Society in Open Pine Forest. Near Reserve.

directly according to the relative values of benefits received. The payments should be made for one year in advance.

11. A definite ratio between different kinds of stock should be established, taking cognizance of the effect of each kind upon the range.

12. The lessee should be required to fence the leasehold within a specified time limit. In case the permit were to a community, a bounding fence should be required, at least, and the division of the lands within this fence be delegated to the community.

13. The development of watering places within certain distances of each other (the maximum limit to be given where practicable) should be required of the lessee. Judgment is required in settling such questions, but the improvement of the range should ever be kept in mind by the official.

14. The protection of the range from erosion and from fire should be required of the lessee, and the rulings should be as rigidly enforced as possible.

15. In so far as possible the residence of the lessee upon his leasehold or nearly adjacent land should be required.

16. Locating, surveying, estimating capacity, inspection, and all such duties should be performed by officers appointed to the service by the Civil Service Commission.

17. A proper court of appeals for settling all disputes should be established.

18. All transactions in connection with the land—offer of permit, rental and other requirements, number and kind of stock allowed on the leasehold, time allowed in which to get it fully stocked, and *all* data of importance to would-be lessees—should be published at stated intervals in a prescribed and proper manner. *This feature of the publicity of all transactions of the bureau in charge is of vital importance.*

### What Have Others Done?

Texas owns her own public lands and has had a leasing system in force since 1883. A most satisfactory resumé of the history of the system of leasing now in use in that state may be found in Forest Service Bulletin No. 62 (p. 32, et seq.). The author of this article, Dr. F. V. Coville, Botanist of the U. S. Dept. of Agric., discusses in detail the growth of the leasing idea in Texas, the terms of the law which they have found most effective, and summarizes fourteen benefits derived, thirteen of which have been received by the stockmen of the state, while the fourteenth (an increased rental) comes to the state as a whole and reduces taxes for everybody in it. Dr. Coville also reports on the methods of leasing public lands belonging to the state of Wyoming, as well as the leasing system in use by the Northern Pacific Railroad for controlling their grazing lands. He then summarizes his studies in a proposed "System for the Regulation of Grazing on the Public Lands of the United States."

New Mexico already has a Territorial land commission which has charge of about 5,000,000 acres of land belonging to the Territory. The total number of acres leased does not appear in the Commissioner's latest report, but he shows \$9,247.24 received for rentals, which accounts for probably not less than 350,000 acres now rented. The system has been in operation but a short time, and no doubt all of the land will ultimately be rented. A system of regulations has been devised by the Commissioner, a printed copy of which may be had for the asking.

Each of the Australian colonies—Western Australia, South Australia, Queensland, New South Wales, and Victoria—as well as New Zealand, has extensive leasing systems in successful operation. Their systems are not alike in the details, but the central idea of each is the same: i. e. a general government official with large discretionary powers, in charge of the public lands and responsible to the highest

executive and the legislative body of the colony. Each of these colonies has large areas of crown lands which may be obtained by homestead, by purchase, or by leasing in a number of different ways. In most of them any kind of crown land may be leased for its proper purpose, as determined by the commissioner in charge, and for a rental commensurate with the value of the land. New Zealand has gone so far as to buy back lands of non-resident private owners who were using agricultural lands for grazing purposes, in order to lease them in small bodies to homemakers. The leasing policy has worked well in practically all variations, mainly because the laws have allowed the commissioner to fit the regulations to the particular conditions under which they have been applied.

Our land laws are not so adjustable; our lands are all assumed to be equally good in the sight of the law. But the application of this assumption and these laws has proven detrimental to our grazing land area. It behooves us therefore to advance to the acceptance of a saner conception of the whole question and adopt a better system of control. There is little doubt in the author's mind that the plan proposed by President Roosevelt is the best yet offered. Attention is called to the one danger of such a system by Dr. Coville in the article already referred to when he says:

"The inauguration of the system would require new legislation. Its success or failure would depend largely on the character of its administration. Discretionary powers are necessary if the law is to be successful in adjusting the equities of range occupants, and these same discretionary powers, if placed in the hands of incompetent or unscrupulous administrators, would bring disaster to the public interests and dishonor to the public service."

The question then resolves itself, as all executive and administrative questions always do, into THE MAN. No worthy citizen of our country doubts for a moment that we have

plenty of men who can perform such duties with credit to themselves and benefit to us.

### Summary

**INTRODUCTION.** The thesis is proposed that it is a wise policy to conserve as far as possible the "material basis" of our national prosperity. The forage crop of our public lands is believed to be a part of this material basis and capable of being conserved.

**AREA AND APPORTIONMENT.** The total area of about 78½ millions of acres is apportioned in Mexican land grants, railroad land grants, Territorial land grants, forest, Indian, and military reserves, patented lands, and public lands. More than 90 per cent of these lands are now valuable for stockraising only and probably will always remain so.

**TOPOGRAPHY.** The salient topographical features of the Territory are set forth with their associated climatic conditions.

**FORAGE PLANTS.** The main grass societies are discussed and the distribution of each is shown on a map. These societies may for convenience be called (1) the Blue Grama society; (2) the Black Grama society; (3) the Colorado Blue Stem society; (4) the Arizona Fescue society; (5) the Water Grass society; (6) the Salt Grass society. A number of other forage plants which are not grass-like are mentioned and the importance of each is noted.

**WEEDS AND POISONOUS PLANTS.** A number of weeds are characteristic of particular kinds of overstocked ranges; and a number of poisonous plants have been pointed out, while a few others remain to be studied.

**CONDITION OF THE RANGE.** Examination of the range shows it to be run down and not nearly as productive as it might be and as it once was.

**THE CUMULATIVE EFFECTS OF OVERSTOCKING.** Stock eat



the valuable forage plants and leave the poor ones, thus giving the latter undue advantages in the struggle for existence. "Skinned" ranges do not hold water; the run-off is greater and more rapid, tending to increase dryness, the cutting away of soil, and the drying up of springs and water courses. A particular example of the effects of overstocking upon the drainage and erosion is given.

**THE CARRYING CAPACITY.** The average carrying capacity for the whole Territory obtained from the acreage and the average amount of stock, as well as it can be estimated, is approximately 35 acres per head per year (of cattle or equivalent). Detailed estimates for different parts of the Territory are given.

**THE FINANCIAL VALUE OF THE RANGE.** An estimate of the value of the range as obtained in several different ways shows that the prices ordinarily paid, viz:  $2\frac{1}{2}c$  to 5c per acre per year, are about what the business will bear.

**THE METHOD OF MANAGEMENT** now in operation is detrimental to the business itself, to the ranges, and for both these reasons to all other industries of the Territory. The lack of legal control and responsibility are the principle characteristics of the present method or rather lack of management.

**THE DESIRABILITY OF A BETTER SYSTEM OF CONTROL.** An *ideal* system would place the land in the hands of as many individuals living upon it as it will support, and this ideal is the thing to be striven for. The important features to be included in any plan of management are to delegate legal control and impose responsibility upon the recipients. Both of these factors tend to the improvement of the range and therefore of the industry.

**THE RESULTS OF CONTROL.** A special case is cited in which control of a large area resulted in a 20 per cent improvement of the range in the course of about three years.

**THE REMEDY PROPOSED.** It is proposed that the public grazing lands be placed under the control of a member of the cabinet and a system of permits or leases be established under rules adapted to each separate region and governed by the conditions obtaining in the region. The fees should be large enough to support the staff necessary to carry the plan into effect. Some of the objections to this plan are considered. Points which must be covered by the regulations are submitted. These are largely based upon the experience of others.

**WHAT HAVE OTHERS DONE?** Attention is called to a resumé of the land laws of Texas by Dr. F. V. Coville, as well as the lease laws of Wyoming and the Northern Pacific Railroad Company. Our own Territorial policy is cited. The extended experience of the Australian colonies has proven that the plan is not only feasible but by far the best land policy yet proposed. The whole question resolves itself into the administration of a policy for the good of the many instead of for the few.

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JUL 14 1908

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MAY, 1908

**New Mexico College of Agriculture and Mechanic Arts**

**AGRICULTURAL EXPERIMENT STATION**

**AGRICULTURAL COLLEGE, N. M.**



**No. 1**

**No. 2**

Number 1 is a promising red variety

Number 2 is one of the variations of the Chile *pasilla* used in the experiments  
The leaves were removed from both plants

**CHILE CULTURE**

BY

**FABIÁN GARCÍA**

ALBUQUERQUE MORNING JOURNAL, ALBUQUERQUE, N. M.

# **New Mexico Agricultural Experiment Station**

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# CHILE CULTURE

## Introduction

The word chile as used in this bulletin is the Mexican name for the English peppers or *Capsica*. As far as the writer knows the name includes all the garden peppers, (*Capsicum annuum*). The name is in general use throughout New Mexico by both English and Spanish speaking people, and this seems to be also true in Mexico and farther south. The different varieties seem to be distinguished one from another usually by a descriptive adjective following the word chile, such as chile *Colorado*, chile *Negro*, chile *Pasilla*, etc.

The chile is used in many different ways and it is quite an important article of food among the Spanish speaking population in the Southwest and in Mexico. It is eaten both in the green and ripe state. Chile is being canned green in Los Angeles, California, and in Las Cruces, New Mexico. The use of chile in the United States is increasing every year; the American people are beginning to cultivate a taste for it, and thus a greater demand is being created for this vegetable.

In this bulletin no attempt will be made to enumerate the different ways in which chile is used, nor to describe the methods of preparing it. It is the intention that such information will be published in a later work.

## Soil

While the chile plant prefers a rich friable loam, it will grow well in heavier soils. The more clay the soil has the more difficult it is to secure a good stand from field planted seed, and more careful cultivation and irrigation is necessary to keep the plants growing well.

### Ridge and Level Culture

In its native home in tropical and southern America the chile seems to be a perennial, though under cultivation in the temperate zone it is always grown as an annual. It may be grown on ridges or in level plats. The former method is the more common in New Mexico. In the spring after the ground has been plowed and leveled (the plowing of the land can be done in the fall or winter) and just a little before planting the ridges are made, with a two horse plow, three and one half feet apart, leaving a narrow furrow between them. These ridges may vary in height from 8 to 12 inches. It is better to irrigate the ridges before planting, though this is not always done. The object of irrigating before planting is to get the water mark on the side of the ridges and to settle the newly plowed soil somewhat. As soon as the soil is dry enough so it can be worked, which is generally from four to seven days, the seed is planted usually on one side of the ridge and just above the water mark. The seed is planted by hand in hills about every two feet in the row. A very good way is to carry a small can along with a little water in it to keep the seed moist enough so it will stick together. An old teaspoon may be used to dig the small holes on the side of the ridge and to dip out the seed. Most chile planters use about a quarter to a half teaspoon full of seed to every hill. This seems to be an unnecessary amount of seed, but it insures a very good stand and it is better to use more at first than to have to replant later. The soil being moist, the seed starts to germinate immediately and very frequently it comes up before the ground needs to be irrigated again. In case, however, that the chile does not come up or that the soil dries up too much, an irrigation should be given in order to complete the germination, though care should be taken not to allow the water to cover over the hills because the soil is liable to bake. If the soil bakes very much, germination is retarded and frequently prevented. When the seed is planted in dry ridges it should be

irrigated immediately afterwards, taking care that the water does not go over the hills for the reason given above. Sometimes a second and even a third irrigation may be necessary to complete the germination.

Planting the seed in level plats is very rarely practiced by the Mexican farmer, though it is believed that under certain circumstances it will give as satisfactory results as the ridge method. After the land has been plowed and properly harrowed and smoothed, the rows are marked off with a marker three and one half feet apart. The seed is then planted by hand in hills two feet apart in the row, or still better, as it is done at the Station, drilled in by means of a Planet Jr. garden drill so arranged that it drops the seed in hills every two feet. After the seed is drilled or planted it is irrigated or flooded. This flooding tends to pack the ground and if the soil is heavy it bakes considerably and cracks open when it begins to dry.

If, after the first irrigation, the soil bakes and retards or prevents the small plantlet from coming up, it is advisable and oftentimes absolutely necessary that a second irrigation be given just about the time the seed is breaking through the crust. This second irrigation should be as light as possible and the water should not remain standing in the squares. If too much water stands in the lower spots the germination is likely to be poorer at those places. If the irrigation could be given in such a way that the water simply moistens the hard crust formed over the seed the stand would undoubtedly be better.

### Time to Plant

The chile being native of tropical countries does not stand freezing weather, though it will stand a little more cold than tomatoes. On the night of October 1st, 1907, the temperature at the Station dropped slightly below freezing. This temperature barely injured the most tender growth of the chile plants while the tomatoes showed the effects of the freeze



quite considerable. The blossoms on the chile plants were slightly hurt, but the pods were not injured. The time to plant the seed out in the field is about the same as for tomatoes, being after danger of frost is over. In the Mesilla Valley there is more or less established date among the Mexican growers for planting the seed. This date is the 19th of March or immediately after. While this is somewhat early, the seed as a rule does not come up until danger of frost is practically over. During years with backward springs, like in 1907, the 19th of March would be too early. At the Station the practice of planting the seed out in the field during the first week in April has given good results.

### Distance Apart to Plant

The distance at which to plant the chile seed varies with different growers; there seems to be no fixed rule among them. The writer has inquired of a number of local growers and none of them seem to have a definite idea about the distance, except that it is well to plant the seed far enough apart so as to permit cultivation with ease. In looking over a number of chile fields it has been found that the distance may vary from three to five feet between the rows and from one to four feet between the plants in the row. After having studied the matter carefully as to the best distance, everything considered, three and a half feet between the rows and two feet in the row has been adopted by the Horticultural Department as the most desirable distances. These distances have given satisfactory results. For the convenience of intending chile growers the following table which gives the number of hills per acre at different distances has been prepared:

| DISTANCE                                            | NUMBER OF HILLS PER ACRE |
|-----------------------------------------------------|--------------------------|
| 3½ feet between rows x 2 feet in the row . . . . .  | 6222                     |
| 3½ feet between rows x 2½ feet in the row . . . . . | 4978                     |
| 4 feet between rows x 2 feet in the row . . . . .   | 5445                     |
| 4 feet between rows x 2½ feet in the row . . . . .  | 4356                     |

### **Planting**

As already explained under the heading "Ridge and Level Culture" the seed is planted on the side of the ridge, when the ridge method is practiced. The southern exposure of the ridge is always preferable since this is usually warmer and the germination, other factors being uniform, is quicker. If level culture is practiced there is no choice of exposure. Whatever method of planting is followed care should be taken not to bury the seed too deeply. As a general thing the seed should not be deeper than three-fourths of an inch to an inch and a half. Shallower planting, if the moisture is kept normal, will give quicker and better germination. More seed is required per acre when the planting is done by hand on ridges than when it is drilled with a garden drill in plats. At the Station it has taken 6.87 pounds of seed per acre on ridges, and 4.38 pounds per acre in the level plats. In case some of the hills fail to come up it will be necessary to reseed or transplant in the vacancies.

### **Thinning**

Chile started from seed planted in the field must be thinned to one or three plants to the hill. As a rule, most of the chile growers do not thin enough, and some do not thin at all. The results at the Station show that thinning to two plants to the hill is very satisfactory. When the chile has been thinned out properly the plant or plants in the hill branch out considerably and produce a heavier and better crop. If too many plants are left to the hill there is a marked tendency for the plants to grow too tall and more or less top heavy. The chile is thinned out when about 3 to 5 inches high. If a good germination takes place it is more difficult to thin the chile, because there are more small plants to the hill to be pulled out. Care should be had in selecting the strongest plants in the hill and in injuring as little as possible the roots of those which remain.

The thinning can be done more easily and quickly if the soil is quite moist. If the plants have come up in bunches those which remain in the hill are necessarily more or less

disturbed by the operation of thinning and these may wilt afterwards, especially if the day is hot and dry. It is advisable to irrigate after thinning, to prevent the wilting of the young plants. The more bunched the plants that come up are the more expensive the thinning will be. The cost of thinning chile in ridges and in plats was noted this year at the Station. The cost per acre on ridges was \$3.33, while on level plats it was \$1.50. The difference in cost of thinning is explained by the fact that considerable more seed was used for the ridges and the plants came up all in a bunch, while in the level plats there was less seed used and the plants were not so close together.

### Transplanted Chile

While the common way of growing chile is to plant the seed out in the field in the spring, it can also be grown by starting the plants in cold frames early in the season and transplanting to the field as soon as danger of frost is over. In fact the crop can be had considerably earlier by this method. The earlier the plants begin to bear, other conditions being equal, the larger the crop, since the chile plant keeps bearing as long as it is growing or until it is killed by frost in the fall. In the fall all stages of the chile may be found upon the plant, from the blossoms to the ripened pods. The plants can be transplanted from the cold frame to the field when they are from three to five inches high. Two plants can be transplanted to each hill in the row. Immediately after transplanting, the plants must be irrigated, and again about a week later. The more stocky the plants are grown in the cold frame, the less the shock they will receive when transplanted. Aside from being nearly as cheap to transplant as it is to plant the seed out in the field, an earlier crop of green chile may be produced. The trouble that is frequently experienced due to field mice eating the seed and the small plants is largely done away with by this method.

The ground should be prepared the same as for seed

planted in the-field. The small plants can be transplanted in rows in level plats, or ridges, or on the side of small furrows. The furrow system has been practiced with good results at the Station. After the ground has been plowed and smoothed over, small furrows are made with a small plow every  $3\frac{1}{2}$  feet. The plants may be irrigated through these furrows with less danger of covering them over with too much water as is often the case in the plats, and, again, less water is necessary for the first irrigations than when the ridge system is practiced.

### Cultivation

The cultivation of chile is similar to that for tomatoes, which consists in keeping the ground as loose as possible and free from weeds. If the ridge method is practiced the cultivations consist in plowing a furrow to the row of chile plants which are planted on the side of the ridge. Since the plants are growing only on one side the dirt plowed against them comes off from the next ridge from the side not having any plants growing. It is customary, though not necessary, to pull up the plowed dirt to the plants with the hoe as the weeds are being hoed out. By means of this method of cultivation the ridge is enlarged on the side on which the plants are growing, so that by the time cultivation stops the rows of plants are in the middle of the ridge which appears as though the plants had been started in the middle instead of on the side.

The cultivation for the chile grown in level plats and for that transplanted on the side of small furrows is somewhat different. In the level culture, the five tooth Planet Jr. cultivator is used to keep the soil loose in the middle between the rows. There is always less hoeing to do in the level culture plats than in the ridges. The cultivation should be kept up during the earlier part of the season so that by the time the plants are bearing, there will be no more need of it, except an occasional hoeing of a few scattering weeds. Some addi-

tional information on this subject may be had by referring to the discussion (page 21) on the cultivation of the experiments conducted at this Station.

### Irrigation

The irrigations necessary to produce germination and to secure a good stand of chile need some consideration, as on these depend to a large extent the success of the crop. After the irrigations to get the crop started have been given, the frequency of the subsequent irrigations depends upon the weather and soil conditions, and for that reason no specific statement can be made just when and how often the chile should be irrigated. One thing, however, is important to keep in mind, and that is that the chile plant keeps bearing as long as it is growing. If the growth should be checked by the lack of irrigation the plant stops bearing and the blossoms and the very small pods are likely to drop off. The grower himself should study his local conditions and decide for himself when and how much to irrigate. While the chile plant resists considerable drought, at the same time, it should not be allowed to suffer from the lack of irrigation. When the chile is grown on ridges the space between the ridges should be allowed to fill with water almost up to the plant. If the water is simply turned in and allowed to rush down the furrow to the other end the ridges will remain practically dry, necessitating frequent irrigations to keep the plants from suffering. In irrigating chile on ridges always aim to hold the water long enough in the furrow for the ridges to get fairly well soaked through.

In the level plat the irrigation is more simple and the soil around each hill gets wet sufficiently while the water is running down to the end of the plat. When the plats are quite long and are made up of a series of squares as soon as each square is filled with water the border, dividing that square from the next one, is cut and the water rushes into the next square which is treated the same as the one before.

### Green Chile

A large amount of the chile is eaten in the green stage. In fact, practically all the chile used during the summer months is green. Before the chile is ready for use it ought to be almost full grown. This stage can be recognized by the green pod having a noticeable bright or shiny luster, and being firm enough to resist considerable pressure when pressed between the thumb and fingers. If pressed tightly the pod will emit a slight crackling sound. When the chile is picked too immature the shrinkage in weight is soon noticed and the pods shrivel so much that the peeling of them becomes more tedious. Green chile for canning purposes should be mature and the pods ought to be smooth and as large as possible. A typical pod for canning should be from 4 to 6 inches long, or longer, and about an inch or more in diameter at the stem end, gradually tapering down to a point. It should be smooth, straight, and fleshy. Aside from taking more time to peel a short wrinkled pod and one sunken at the stem there is more waste to it.



Figure 1. Picking Green Chile.

A number of pickings of good, mature, green chile for canning purposes can be made during the season. The earlier the plants come into bearing and the better care they receive, the more green chile they will produce. At the Station during the season of 1907 the experimental field planted plats were picked six times, while the transplanted plants from the cold frame were picked nine times. The picking of the green chile is somewhat slow and the pickers, aside from being careful not to break the branches containing smaller pods and blossoms, should be quick with their hands and able to tell at a glance a pod that is mature enough for the cannery without having to stop and examine it. It takes some little experience to pick good chile and pick it fast. At the Station it was observed that young inexperienced pickers at first picked very slowly and the larger part of the chile they picked had to be sorted over before it was sent to the cannery. The amount of chile the average experienced person can pick depends upon the crop of mature pods the plants have at the time. Since the amount varies it is impossible to give definite figures for all cases, but from six different pickings at the Station in 1907, the men picked from 35.5 to 45.5 pounds per hour.



Figure 2.  
Green Chile  
Picked for  
the Cannery.

Green chile can be kept for home use for some time after the crop has been gathered, by placing the green pods in dry sand, or, by piling up the vines and keeping the pods from freezing. In this way green chile may be had for use part of the winter months. If green chile is placed out in the sun it will turn yellowish white and become worthless, while if placed in the shade it will color up, and can be used as red chile.

### Red Chile

*Red Chile* is the term generally used for ripe pods whether they are red, black, or other colors. If no green chile is picked from the plants during the summer season two different pickings may be made of ripe pods. The first picking may be made whenever there are enough of the ripe pods on the plants to pay, while the last picking is made just before it freezes. The pods ought not to be picked until they are perfectly ripe. If picked partially unripe the green parts of the pods will be of a yellowish white color when they are dried in the sun. After the red chile is picked it has to be dried before it can be stored. Two methods for drying the chile are practiced by the Mexican chile growers. The most common



**Figure 3. Ripe Chile in Piles Preparatory to Spreading it Out to Dry in the Sun.**



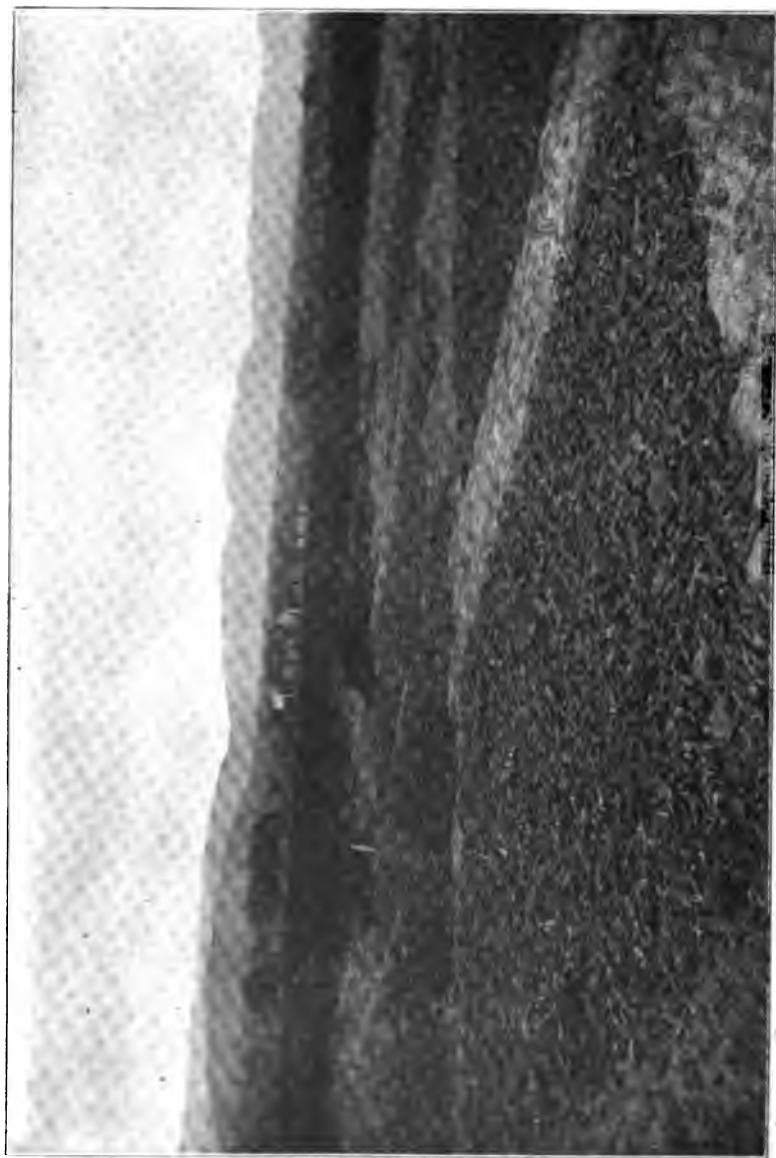
way is to pile it up in medium sized piles, (See figure 3) from 4 to 6 days. At the end of this period the chile is spread out on the ground about two pods thick, and left there until thoroughly dried, when it is sacked and stored or shipped away.

It is claimed that by leaving the chile in piles for a few days before it is spread out the dry pods will be more fleshy than when not submitted to this treatment. The other and less common way of drying it is by tying four or six pods together and making long festoons which are then hung out where they will dry (See figure 4).



Figure 4. Drying Ripe Chile Tied in Festoons.

Air dried chile is very light and bulky. The dry pods will not stand any pressing without breaking. The time it takes chile to dry when spread out on the ground in the fall varies from 6 to 8 weeks. The red chile loses considerable in weight during the drying process. The amount of weight lost depends to some extent upon the quality of the pods. If the pods are all perfectly ripe and sound when picked the loss will be less than if the pods are more or less green. From 2819 pounds of fresh ripe chile, containing some pods that were not perfectly ripe, put out to dry November 8, 1907, 747 pounds of dry chile were sacked and weighed January 2, 1908. According to these figures there were 2072 pounds loss, or 73.5% of the original weight. On November 8, 1907, fifty pounds of selected fresh ripe pods were spread out to



**Figure 6. Ripe Ohlve Spread Out to Dry in the Field.**



Figure 6. Sacking the Dried Ripe Chile

dry and from this lot 16 pounds of the dried chile were weighed and sacked January 2, 1908. Thus it is seen that the loss in weight was 34 pounds or 68%. Another 50 pounds of good, matured green chile were spread out on the same date and when dried it weighed 10 pounds. In this case the original weight was reduced 40 pounds or 80%. From these two tests it is noticed that the difference between the green and ripe chile was 6 pounds or 12% in favor of the ripe pods. The amount of red chile produced per acre can be increased by drying the green chile picked in the fall in the shade.

In the preparation of the red or green chile for use the flower stems, seeds, and veins\* are discarded, and represent so much waste. Aside from being quite a task to remove the

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\*The word veins as used in this bulletin is a literal translation of the Spanish word *venas*, which is the common Spanish name given in this section to the *placenta* or the pithy core in the chile pod. The author has adopted the word *veins* on account of not having found a better common term for the *placenta*.

stem and seeds from the pod, the fine dust coming off from the chile is exceedingly irritating to the nostrils and eyes. In order to obtain some data on the proportion of stem, veins, and seeds to the pod and the time necessary to remove these, 50 pounds of ripe, dry pods were weighed and the waste removed. The following are the results in figures:  $29\frac{3}{4}$  pounds of clean pods,  $5\frac{1}{4}$  pounds of stems,  $\frac{1}{2}$  pound of veins, and  $14\frac{1}{2}$  pounds of seed. It took  $23\frac{1}{2}$  hours to remove the stems, seeds, and veins from the pods. From these figures it will be seen that there is a large waste to red chile. Taking into consideration so much waste and the amount of work required to remove it and the disagreeable features of the work, it would be better for the consumer to buy the cleaned pods. Ordinarily the red chile is retailed locally at 15 to 20 cents a pound. Taking the 50 pounds of red chile they would bring from \$7.50 to \$10.00. Then according to these figures the consumer pays 15 to 20 cents per pound or \$3.03 to \$4.05 for the  $20\frac{1}{4}$  pounds of waste in the 50 pounds of chile bought, plus \$2.35, the cost of removing the stems and seed. In other words, the  $29\frac{3}{4}$  pounds of cleaned pods cost the consumer \$9.85 to \$12.35 or approximately at the rate of 33 to 41 cents

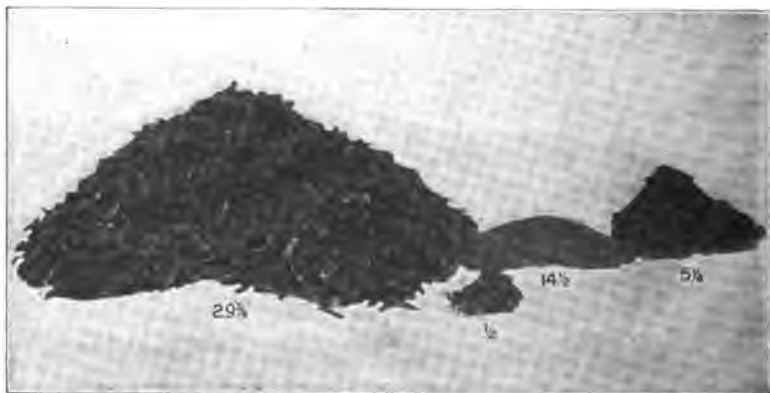


Figure 7. 50 lbs. of Ripe Dry Chile Showing Proportion of Clean Pods  $29\frac{3}{4}$  lbs. Veins or placenta  $\frac{1}{2}$  lb. Seeds  $14\frac{1}{2}$  lbs. Stems  $5\frac{1}{4}$  lbs.

per pound. Without dwelling too long upon this point it might be said that the consumer could better afford to pay 30 to 40 cents per pound for the cleaned pods than 20 cents for the uncleaned pods.

Red Chile, as now dried in this country, is very bulky and very light. One *fanega* in bulk which is equivalent to  $2\frac{1}{2}$  bushels weighed 12 pounds, and  $7\frac{1}{2}$  pounds without the stems and seeds.

### Seed

The chile seed resembles the tomato seed except that it is brighter in color and smoother. The same amount of care should be exercised in the selection of chile seed as for any other vegetable. As a matter of fact, our New Mexico chile-growers do not pay any attention to the selection of the seed, and as a result of this we are producing a very variable product.

### Diseases

So far there are no diseases troubling the chile. Once in a while a grower complains of some of the plants dying out. This occurs as a rule with plants growing in the lower spots in the field and where the soil is very heavy. It seems that the probable cause is too much water being allowed in the low places, causing the souring of the soil. Last year one or two growers complained of the very small chile pods and blossoms occasionally falling off. On investigation of this trouble no disease of any kind could be discovered on the plants, but it looked like the trouble was due to the plants having been allowed to dry too much, and thus, materially reducing the plant food of the more delicate parts of the plant. When the plants were irrigated they freshened up and new growth and fruit buds were stimulated, while the blossoms and newly formed pods which had suffered dropped off.

### **Insects and Mice**

There are few garden crops in New Mexico which have less insect enemies than the chile. The worst insect pests at present are the grasshoppers and the large green tomato worm.

The field mice do considerable damage in the spring, by eating the seed planted in hills. The little plants are also cut off just below the seed leaves. This trouble is likely to be worse in new and sandy loam especially if the adjoining field is unbroken and full of weeds. The only way to reduce the loss from these mice is to kill them, which may be done by putting out baits such as poisoned wheat and chile seed.

### **Station Test**

During the year 1907 the following chile experiments were conducted at the Station: Ridge vs. level culture from field sown seed; field sown seed vs. transplanted plants from seed started in cold frames; yield and cost of production of green and red chile per acre; effects of sodium nitrate upon yield. The land used for the field planted chile was the same which was used for melons during 1906. The soil in these plats is a very light loam and easily worked. On some of the plats there were a few small alkali spots on which it was almost impossible to secure a good stand. The land was winter plowed and disced. Two acre plats were laid off, one was ridged and one was not. On the ridged plat the seed was planted on the side of the ridge two feet apart according to the method already described under Ridge Culture, page 5. The ridges were made with a two-horse plow three and a half feet apart. On the level plat the seed was drilled in with a Planet Junior drill. The rows were first marked off three and a half feet apart with a hand marker. The drill was so regulated that it dropped the seeds in hills every two feet in the row. The plats were not irrigated before planting the seed as is often done. The seed was planted in the dry soil, and the first irrigation to produce germination was given immediately after planting the seed.

## Field Planted Chile

The following is a statement of the different operations on both the ridged and level culture one-acre chile plats for the season:

|                    |                                                                 | Ridge<br>Culture<br>Plat | Level<br>Culture<br>Plat |
|--------------------|-----------------------------------------------------------------|--------------------------|--------------------------|
| April 3-4, 1907    | Making ridges 3½ ft. apart with a 2-horse plow .....            | \$ 2.40                  | .....                    |
| April 4, 1907      | Disking ground before planting .....                            | .....                    | \$ 1.20                  |
| April 4, 1907      | Smoothing after disking .....                                   | .....                    | .60                      |
| April 5-10, 1907   | Planting seed every 2 feet on side of ridges by hand .....      | 3.35                     | .....                    |
| April 10, 1907     | Marking rows 3½ feet apart with hand marker .....               | .....                    | .40                      |
| April 10, 1907     | Drilling seed with garden drill .....                           | .....                    | .50                      |
| April 12, 1907     | Irrigating with well water, gasoline and labor .....            | 1.94                     | 2.41                     |
| April 20, 1907     | Irrigation with ditch water .....                               | 1.00                     | 1.00                     |
| May 7, 1907        | Replanting vacancies with drill ....                            | .....                    | .35                      |
| May 14, 1907       | Irrigation with ditch water .....                               | .60                      | .60                      |
| May 20, 1907       | Irrigation with ditch water .....                               | .60                      | .60                      |
| May 27-28, 1907    | Hoeing .....                                                    | .60                      | 1.30                     |
| May 30-31, 1907    | Transplanting in vacancies and irrigating with well water. .... | 1.50                     | 3.80                     |
| June 4-5, 1907     | Hoeing .....                                                    | 1.50                     | .....                    |
| June 6, 1907       | Cultivating with 1-horse cultivator ..                          | .....                    | .40                      |
| June 7, 8-11, 1907 | Transplanting and irrigating .....                              | .....                    | 2.65                     |
| June 20-21, 1907   | Cultivating with 1-horse cultivator ..                          | .....                    | .50                      |
| June 22-24, 1907   | Hoeing .....                                                    | .....                    | 1.05                     |
| June 28-30, 1907   | Thinning plants .....                                           | 3.33                     | 1.50                     |
| July 1, 1907       | Hoeing .....                                                    | .80                      | .....                    |
| July 5, 1907       | Partial cultivation .....                                       | .....                    | .35                      |
| July 12-13, 1907   | Irrigation with well water .....                                | 1.17                     | 1.25                     |
| July 17-18, 1907   | Plowing dirt up to plants .....                                 | 2.40                     | .....                    |
| July 18, 1907      | Hoeing and drawing dirt up to plants ..                         | 1.70                     | .....                    |
| July 19, 1907      | Hoeing .....                                                    | .....                    | 2.45                     |
| July 19, 1907      | Cultivating .....                                               | .....                    | .60                      |
| July 29, 1907      | Cultivating .....                                               | .....                    | .40                      |
| Aug. 6, 1907       | Irrigating from ditch .....                                     | .60                      | .67                      |
| Aug. 15-16, 1907   | Irrigating from well .....                                      | 1.20                     | 1.20                     |
| Aug. 31, 1907      | Cultivating .....                                               | .....                    | .40                      |
| Sept. 2, 1907      | Cultivating .....                                               | .....                    | .40                      |
| Sept. 9, 1907      | Irrigating from well .....                                      | 1.00                     | 1.08                     |
| Oct. 7, 1907       | Irrigating from ditch .....                                     | .50                      | .70                      |
|                    |                                                                 | \$26.19                  | \$28.36                  |

From this table it is seen that the plats were irrigated with ditch and well water. The reason for this is that oftentimes the water from the ditch was not available and it was more convenient to use the pump. The first irrigation, which was given with well water, cost more than any other subsequent irrigation. As a rule it takes more water for the first irrigation in the spring after the ground has been plowed and worked over. Again, it is noticed that it cost considerable to irrigate the plats when ditch water was used. This is ex-

plained by the fact that the farm is irrigated from a high and very long lateral that is not yet well established. Every time the farm is irrigated extra help has to be hired to watch the ditch to keep it from breaking at the weak places and also to watch the headgate at the main ditch. Notwithstanding the high cost of irrigating from the ditch due to the necessary extra labor, it was still cheaper than well irrigation.

Owing to the fact that there was poor germination in the level culture plat, probably due to the seed having been drilled in too deeply, it was necessary to reseed most of the plat. During May 26, 27, 28 heavy winds blew from the southeast and caused considerable damage to all the chile, but more particularly to the level culture plat since this was close to a sandy area and the sand blowing in from this side covered up and killed a great many of the chile plants. On account of these winds injuring so much of the chile, it was necessary to do considerable transplanting later in the season. In the level culture plat there were a few alkali spots in which it was almost impossible to secure a stand and for this reason no doubt the yield was somewhat reduced. On account of the very unfavorable spring, the plants were exceedingly slow in getting a good start, making the crop very late. The thinning, which was done about the 28th of June, would have been done considerably earlier if the season had been normal. The first green chile from these plats was picked August 26th. The cost of production, not including the picking, of the ridged and level plats was \$26.19 and \$28.36, respectively. If all the irrigations had been given with ditch water and if the farm lateral had not given so much trouble, and if the season had not been so unfavorable the cost, it is believed, would have been somewhat smaller. In most cases, it cost a little more to irrigate the level plat than it did the ridged acre. It cost \$2.17 more to produce the level acre plat than it did the ridged acre. It is believed, however, that if the seed had not been drilled quite so deeply in the first place, and if the wind and sand had not injured such a large percent of the plants on the



level culture plat, the reseeding and transplanting of this plat might have been avoided and the cost would have been considerably less than for the ridged plat. The ridged plat was irrigated 10 times and the level culture plat 11 times during the season. Two of these irrigations would have been avoided if transplanting had not been necessary.

### Transplanted Chile

In order to get data on the cost and on the yield of transplanted chile a plat\* 38/100 of an acre was prepared among the trees in the peach orchard and transplanted with plants started in a cold frame.

The following is a statement of the cost of producing the transplanted 38/100 of an acre plat, not including the picking:

|                 |                              |         |
|-----------------|------------------------------|---------|
| Feb. 8          | Planted seed in cold frame   | \$ .45  |
| Feb. 8-April 30 | Care of cold frame           | 1.20    |
| April 30        | Preparing plat—man and team  | 1.00    |
| April 30        | Transplanting and irrigating | 2.05    |
| May 3           | Irrigating                   | .15     |
| May 14          | Irrigating                   | .15     |
| May 20          | Irrigating                   | .15     |
| June 3          | Irrigating                   | .15     |
| June 6          | Cultivating                  | .15     |
| June 8          | Hoeing                       | 1.00    |
| June 21         | Cultivating                  | .10     |
| June 26         | Irrigating                   | .25     |
| June 29         | Hoeing                       | .55     |
| July 6          | Hoeing                       | .80     |
| July 10         | Irrigating                   | .25     |
| July 15         | Irrigating                   | .25     |
| July 29         | Cultivating                  | .15     |
| Aug. 6          | Irrigating                   | .25     |
| Aug. 9          | Cultivating                  | .15     |
| Aug. 21         | Cultivating                  | .15     |
| Aug. 28         | Irrigating                   | .25     |
| Sept. 3-4       | Hoeing                       | .80     |
| Sept. 9         | Irrigating                   | .25     |
| Oct. 5          | Irrigating                   | .15     |
|                 |                              | <hr/>   |
|                 |                              | \$10.80 |
| Per acre        |                              | \$28.42 |

By means of this statement a comparison can be made of the cost of production between the transplanted and field planted chile. The cost of the irrigations is estimated because in irrigating the chile in the four middles in the peach orchard, four rows of peach trees were irrigated at the same time. The cost of producing the 38/100 acre transplanted plat which was

\*All the chile in this plat was picked in the green state.

\$10.80 or \$28.42 per acre, is 6 cents more than for the field planted level culture plat and \$2.23 more than for the ridged plat. The soil selected for this experiment is quite light, easy to work, and not very weedy. After the plat had been plowed and leveled, shallow furrows were plowed out with a single horse plow at a distance of three and a half feet apart. The plants, which were quite stocky and averaging about four to five inches in height, were transplanted on one side of the furrow, two plants to the hill, every two feet. Immediately after transplanting the plants were irrigated. The first few irrigations were given through the furrows. After the first cultivation the furrows were filled up and thereafter the whole surface was flooded over every time the chile was irrigated. Very few of the plants failed to grow. The stand was so uniform that it was not necessary to transplant any of the vacancies. A portion of the plat, containing 11/100 of an acre was fertilized with sodium nitrate.

### Yield Test

Four  $\frac{1}{8}$  acre plats were measured off in the ridged acre and used in the yield test. Two of these plats were fertilized and two were not. The chile from one fertilized plat and one



Figure 8. Transplanted Chile in a Young Peach Orchard.

not fertilized was picked green and weighed as fast as it was ready; in the other two plats the chile was allowed to ripen before it was picked. Four other  $\frac{1}{8}$  acre plats were laid off in the level culture plat and similarly treated to get the yield of green and red chile.



**Figure 9. Vacant Spot in the Level Culture Plat Due to Alkali.**

In the field planted chile, 6 pickings of green chile were made and none of the plats produced at the same rate that the transplanted plats did. With the single exception of plat 4, ridge culture, the ridged plats produced more than the corresponding level culture plats. Probably the vacant spots in the level culture plats, due to alkali, were responsible for some of the differences in yield. It is interesting to note that the fertilized ridged and level culture green chile plats produced less than the corresponding plats not fertilized.

The following table gives the dates and amounts in pounds of the different pickings, the yield per plat, and estimated yield per acre, of the transplanted, ridged, and level culture fertilized and unfertilized plats:

Table I.

| Date harvested                    | Area in acres | Green or Ripe plat | Picked Green |       |       |       |       |       |       |       |       |      | Picked Ripe                        |                               | Estimated total yield per acre pounds | Estimated gain in pounds |       |       |
|-----------------------------------|---------------|--------------------|--------------|-------|-------|-------|-------|-------|-------|-------|-------|------|------------------------------------|-------------------------------|---------------------------------------|--------------------------|-------|-------|
|                                   |               |                    | 8-1          | 8-8   | 8-15  | 8-22  | 9-4   | 9-17  | 10-11 | 10-15 | 10-25 | 11-6 | 11-6                               |                               |                                       |                          |       |       |
|                                   |               |                    |              |       |       |       |       |       |       |       |       |      | Estimated yield in per acre pounds | Plat yield in per acre pounds |                                       |                          |       |       |
| Transplanted Plats                |               |                    |              |       |       |       |       |       |       |       |       |      |                                    |                               |                                       |                          |       |       |
| I Fertilized .....                | 11-100        | Green              | 46           | 62    | 84    | 170   | 123   | 620   | 353   | ..... | 722   | 52   | 9232                               | 20230                         | 58                                    | 527                      | 29817 | 2890  |
| II Not Fertilized                 | 27-100        | Green              | 87           | 140   | 116   | 378   | 470   | 1205  | 815   | ..... | 1174  | 274  | 4680                               | 17250                         | 183                                   | 677                      | 17927 | ..... |
| Field planted level culture plats |               |                    |              |       |       |       |       |       |       |       |       |      |                                    |                               |                                       |                          |       |       |
| I Fertilized .....                | 1-8           | Green              | .....        | ..... | ..... | 135   | 92    | 235   | 445   | ..... | 317   | 150  | 1374                               | 10992                         | 192                                   | 1536                     | 12528 | ..... |
| II Not Fertilized                 | 1-8           | Green              | .....        | ..... | ..... | 218   | 92    | 345   | 326   | ..... | 264   | 118  | 1383                               | 11064                         | 198                                   | 1564                     | 12648 | 120   |
| III Fertilized...                 | 1-8           | Ripe               | .....        | ..... | ..... | ..... | ..... | ..... | ..... | 375   | ..... | 91   | 466                                | 3728                          | 617                                   | 4936                     | 8664  | ..... |
| IV Not fertilized                 | 1-8           | Ripe               | .....        | ..... | ..... | ..... | ..... | ..... | ..... | 523   | ..... | 151  | 674                                | 5392                          | 655                                   | 5240                     | 10632 | 1968  |
| Field planted ridged plats        |               |                    |              |       |       |       |       |       |       |       |       |      |                                    |                               |                                       |                          |       |       |
| I Fertilized .....                | 1-8           | Green              | .....        | ..... | ..... | 154   | 104   | 438   | 479   | ..... | 430   | 118  | 1723                               | 13764                         | 125                                   | 1000                     | 14784 | ..... |
| II Not Fertilized                 | 1-8           | Green              | .....        | ..... | ..... | 153   | 160   | 427   | 687   | ..... | 286   | 95   | 1808                               | 14462                         | 160                                   | 1280                     | 15744 | 960   |
| III Fertilized...                 | 1-8           | Ripe               | .....        | ..... | ..... | ..... | ..... | ..... | ..... | 724   | ..... | 142  | 866                                | 6928                          | 553                                   | 4416                     | 11344 | 1836  |
| IV Not fertilized                 | 1-8           | Ripe               | .....        | ..... | ..... | ..... | ..... | ..... | ..... | 605   | ..... | 238  | 843                                | 6744                          | 408                                   | 3264                     | 10008 | ..... |

The yield of ripe chile from any of the four plats grown for this purpose was somewhat low. On October 15 practically all of the green chile on the vines in the four ripe chile plats was picked, because a freeze was expected just about

then, and green chile will not stand freezing. After the green chile had been picked the temperature rose and there was no freezing weather for about three weeks later. Had not the green chile been picked it is believed that most of it would have ripened by November 6 and the yield of red chile would have been materially larger. In the level culture experiment the total estimated yield from plat 3, which was fertilized, was 1968 pounds less than from plat 4 not fertilized. Part of this difference in yield in favor of plat 4 not fertilized may be due to the fact that it had a somewhat better stand. The total estimated yield from the ridged and fertilized plat No. 3 was 1336 pounds more than from plat 4 not fertilized. This is the only fertilized plat in the field planted chile which produced more than the corresponding plat not fertilized. The lack of uniformity of yield from the different plats makes it exceedingly difficult to say whether the fertilizer was a benefit or not. These conflicting results make the investigations that much more interesting, and the value or detriment of the fertilizer on the crop can only be ascertained by future experiments.

On the whole the transplanted plats produced more per acre than the field planted chile. The average estimated yield per acre of the transplanted, level culture, and ridged culture plats was

Table 11. The following data will give an idea as to the number of pounds of chile that may be picked per hour:

| Date Picked | Area          | Aug. 26 |      | Sept. 4 |      | Sept. 17 |      | Oct. 1 |      | Oct. 24 |      | Nov. 6 |       | Total Number |       | Average number lbs picked per hour |
|-------------|---------------|---------|------|---------|------|----------|------|--------|------|---------|------|--------|-------|--------------|-------|------------------------------------|
|             |               | lbs.    | hrs. | lbs.    | hrs. | lbs.     | hrs. | lbs.   | hrs. | lbs.    | hrs. | lbs.   | hrs.  | lbs.         | hrs.  |                                    |
| Plat        |               |         |      |         |      |          |      |        |      |         |      |        |       |              |       |                                    |
| I           | Transplanted  | 548     | 14   | 493     | 14½  | 1825     | 40   | 1169   | 32   | 1808    | 48   | 916    | 25.5  | 6847         | 174   | 39.3                               |
| II          | Field Planted |         |      |         |      |          |      |        |      |         |      | 1462   | 36.75 | 1462         | 36.75 | 39.7                               |

19373, 11118, and 12970 pounds, respectively. Noting the large difference in yield and the comparatively small difference in cost of production with the transplanted and field planted chile, it would pay the chile grower to start the plants in a cold frame and transplant them instead of planting the seed out in the field.

Sodium nitrate was used as a fertilizer and was scattered along the rows in the plats, four different times during the season. It was applied at the rate of 75, 100, 125, and 150 pounds per acre on July 5 and 19, August 8 and 21, respectively. The total amount being at the rate of 400 pounds per acre.

From this table it is seen that 39.5 pounds of chile was the average number of pounds picked per hour during the season. Some men will be able to pick a little more than this, while others will pick less. The amount picked will also depend upon the crop on the plants at the time of picking. The cost of picking an acre during the season will be influenced largely by the yield, and it will be impossible to give definite figures. However, some idea may be had by making the calculation from the data at hand. The average number of pounds picked per hour during the season was 39.5 and the average estimated yield per acre for green chile from the six plats was 14,487. (See table I) Then according to these figures, it would take 366.7 hours to pick the crop which at the present price of labor, 10 cents per hour, would amount to \$36.67 per acre.

### Varieties

The common Mexican chile that has been grown in this section for a number of years is exceedingly variable and of poor grade. The lack of selection and improvement of this chile is clearly seen in the numerous different shapes, colors, and sizes of the pods. On the whole, the old strain of Mexican chile is not large or good enough for the cannery and it is

being replaced in the Mesilla Valley by two other better varieties which have been introduced in late years. These two varieties produce larger and better pods. One of them has very dark red, almost black pods, while the other has bright red pods when ripe. These two varieties are distinguished one from the other by their color and are known as chile *colorado* (red chile) and chile *negro* (black chile). The tests at the station were made with these two varieties, the seed of which was bought of Mr. Theo. Rouault of Las Cruces, New Mexico. The red variety is a good grower and very prolific (See 1 frontispiece). The vines which grow to about 2½ feet high, branch out considerably and are not brittle, being strong enough to hold up a heavy crop without breaking. The pods are very smooth and of good size, being from four to six inches long and about an inch in diameter at the stem and tapering to a point. The crop ripens very uniformly and this variety is more promising than the black.

The black variety has vines from two to three feet in height and are quite brittle, breaking somewhat when the chile is being picked. The pods do not ripen very uniformly and are not, as a rule, as smooth as those of the red variety. When the ripe pods are being dried, many of them tend to discolor or turn yellowish usually around the stem end, while others become musty on the inside around the veins and seeds. This variety was introduced from Mexico in 1903 by Francisco Rivera of San Miguel, New Mexico; while the red variety was introduced from California in 1902 by Mr. Theo. Rouault of Las Cruces, New Mexico.

### Plant Breeding Work

Taking into consideration the adaptability of the chile plant to this section, its usefulness as a vegetable, the marked lack of uniformity of the crop, and the need of better varieties the work of improving the Mexican chile was begun during the summer of 1907. The work will be carried on mainly by

selection. Three varieties were planted from which to select different strains for future work. These were the red and black varieties secured from Mr. Theo. Rouault of Las Cruces, New Mexico, and the chile *pasilla* obtained from Chihuahua, Mexico, through the kindness of Carlos Romero, an agricultural student of this institution. The chile *pasilla* seems to be the variety generally grown in Chihuahua. Seed for thirty hills was secured. The most noticeable feature with the chile *pasilla* grown in the experimental plat was the very marked variability among the hills. There were hardly two plants that were similar enough to be classed together as the same variety. The variability among the plants of this variety manifested itself in many different ways, mostly in shape, size, and color of the pods, in the size and stockiness of the plant, and in the bearing qualities. The variation was so marked that a number of strains were selected from the chile *pasilla* plants for future work, while in the red and black varieties there was less variation.



Figure 10. Variations Selected for the Plant Improvement Work.  
 No. 1 is a Black Chile Variation.  
 No. 2 is a Red Chile Variation.  
 All the Other Numbers are *pasilla* Chile Variations.



### Summary

1. Chile is very successfully and quite extensively grown throughout New Mexico. It is an important vegetable among the Mexican population, and the American people are beginning to use it more than formerly.

2. Chile is canned green and it is eaten in the green, ripe, and canned form.

3. The common method of growing chile is to plant the seed on the side of ridges at the edge of the water mark, though occasionally it is grown in level plats. A very good method, but one which is not practiced, is to grow the chile in level plats from transplanted plants started in cold frames early in the season.

4. At the station the transplanted plants from the cold frame bore earlier and produced a larger crop than the field planted chile.

5. The distance at which to plant the seed in the field varies considerably with the different growers, though at the station on good average soil  $3\frac{1}{2}$  feet between the rows by 2 feet in the rows has given very satisfactory results.

6. In field planted chile more seed than necessary is used to get a good stand. At the station, at the distances given above, 6.87 pounds and 4.38 pounds per acre were used in the ridged and level culture plats, respectively.

7. Chile plants are tender, though not quite as tender as tomato plants, and therefore the seed should not be planted in the field until danger of frost is over. In the Mesilla Valley many chile growers begin to plant as early as the 19th of March, but the safest time is probably after the 1st of April. For transplanting to the field the seed should be started in cold frames as early as the last of January.

8. Chile seed is somewhat slow to germinate and should not be planted more than  $\frac{3}{4}$  to  $1\frac{1}{2}$  inch deep .

9. To get a good uniform crop of pods, other conditions being favorable, thin the hills to two plants and when transplanting put two plants in a place.

10. The chile plant keeps bearing, if kept continuously and vigorously growing, until frost, at which time all stages of chile from the flower to the ripened pod may be found upon the plants. Thus careful attention must be paid to the cultivation and irrigation. Ten irrigations were given to the field planted chile at the station in 1907.

11. Green chile for home use or for canning purposes should be picked when about full grown and before it begins to color. The picking of the chile is very slow. At the station the average amount picked for the season was 39.5 pounds per hour.

12. One or two pickings can be made of ripe chile during the season. The pods should be perfectly ripe when picked; if partially green they are likely to discolor when being dried in the sun.

13. According to the common method of preparing the ripe chile there is about  $\frac{2}{5}$  of it by weight, that is waste.

14. As yet the chile is not troubled with any serious insects or fungus pests.

15. On the whole the results with sodium nitrate were somewhat contradictory, though in the transplanted chile the fertilized plat showed up satisfactorily.

16. The common native chile is very variable and needs to be improved.

17. The chile investigations have not been carried on long enough to arrive at definite conclusions and the results in this bulletin are only tentative.

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**AUGUST, 1908.**

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**New Mexico College of Agriculture and Mechanic Arts**

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**AGRICULTURAL EXPERIMENT STATION**

**AGRICULTURAL COLLEGE, N. M.**

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**INJURIOUS INSECTS**

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**BY**

**FABIÁN GARCÍA.**

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**SANTA FE, N. M.  
NEW MEXICAN PRINTING COMPANY  
1908.**

# **New Mexico Agricultural Experiment Station.**

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## INTRODUCTION

This bulletin is intended primarily to disseminate information among the gardeners, fruit growers, and farmers of the Territory in regard to those injurious insects which are now known to be more or less troublesome in this section and those that are likely to become pests in the future. It is not the intention to set forth results of original investigations but to present in an intelligible and in as practicable a way as possible the more important points connected with injurious insects which generally are of importance to the plant grower. These are, the life histories of the insects in question, the remedies, and the preventive measures. The life histories have been written as concisely as possible yet explicit enough to enable one to identify the troublesome creature. Special attention has been given to the different remedies as well as to the preventive measures that have been tried and are recommended by the different authorities throughout the country. In searching for this information it has been observed in a number of cases that the remedies recommended have a very narrow margin of applicability yet for the want of something more practicable and more effective they are mentioned in this bulletin.

The information on remedies, preventive measures, and life histories has been drawn from bulletins of a few of the experiment stations, publications of the United States Department of Agriculture, and from standard books on entomology. Smith's, Comstock's, Hunter's, Chittenden's, Saunders's, and Sanderson's works in particular have been consulted in regard to the life histories of the different insects mentioned in this bulletin.

The reason for issuing this bulletin is the increasing demand from farmers throughout the Territory for information on injurious insects. The questions commonly asked by farmers in regard to the insects troubling their crops are, "What is this insect and what are the best remedies?" These questions we have tried to answer in this bulletin.

In dealing with injurious insects prompt action, repeated use of the proper insecticide, and attention to the preventive measures cannot be too strongly emphasized.

### **Biting and Sucking Insects**

Two groups may be made of injurious insects as far as their eating habits are concerned, that is, they are either biting or sucking. In the latter group are included those insects which injure the plants by inserting their tube-like mouth parts through the bark of the plant into the softer tissue and sucking up the sap of the plant. All of the aphids, or plant lice, San José scale, squash bug, and chinch bug are good representatives of the sucking insects.

The biting insects are those that have well developed mouth parts and which chew and swallow some part of the plant or fruit as their food. The caterpillars commonly known as "worms," grasshoppers, and beetles are good examples of the biting insects.

Poisonous insecticides such as Paris green, arsenate of lead, and other arsenical mixtures which can be applied to the part of the plant that is eaten by the insect are the surest remedies. These remedies can not be used effectively on sucking insects because they do not chew and swallow their food. A mixture that kills by contact with the insect body such as the kerosene emulsion, soap solutions, and lime sulphur wash should be used for the sucking insects.

Before applying any of the insecticides a thorough knowledge of the eating habits of the insect injuring the plant should be had. If it is found to be a biting insect, use some one or more of the arsenical mixtures. If, on the other hand, it is a sucking insect then use the emulsions or washes.

In order to properly understand the descriptions and habits of the insects treated in this bulletin a brief explanation of terms has been thought advisable. If we expect to destroy injurious insects we must know how the insect passes the winter, and how many broods there are each year, when to spray, what to spray with, or when to use other preventive measures. All insects have life cycle or metamorphosis. There are two distinct kinds of metamorphosis, complete and incomplete.



### Complete Metamorphosis

Insects with complete metamorphosis (such as the codling moth and Colorado potato beetle) pass through four complete stages of life, the egg, the larva, the pupa, and the adult.

The larval is, in many insects, the stage when the insect does the most damage, while in others the insect is most destructive in the adult stage. In the pupal stage the insect is usually dormant.

### Incomplete Metamorphosis

The insect with incomplete metamorphosis such as the grasshopper and squash bug have only three life stages; the egg, the nymph, and the adult. There is no transformation between the nymph and adult stages as there is between the larva and the adult in insects with complete metamorphosis. The nymph resembles the adult but is generally lacking in some of the organs which when developed complete the growth.

### How Insects Pass the Winter

Different insects vary as to the manner of passing the winter; the grasshopper spends the winter in the egg; the codling moth spends the winter as a larva; the tomato worm winters as a pupa; and the chinch bug winters in the adult stage.

The adult stage is spent, in many insects, mostly in egg laying and is, as a rule in such cases, shorter than the other stages.

### Garden Insects

**Cabbage Aphis** (*Aphis brassicae*, Linn.)—This insect which is one of our cabbage enemies makes its first appearance in the early summer, and remains on the plant until late in the fall. The broad leaves, close together on the head afford an excellent shelter for these aphids. They occur in large numbers and feed in colonies, being easily recognized by a grayish color caused by an excretion from the insects. The insect is quite common in New Mexico.

*Remedies.*—Clean culture is very important in the field as

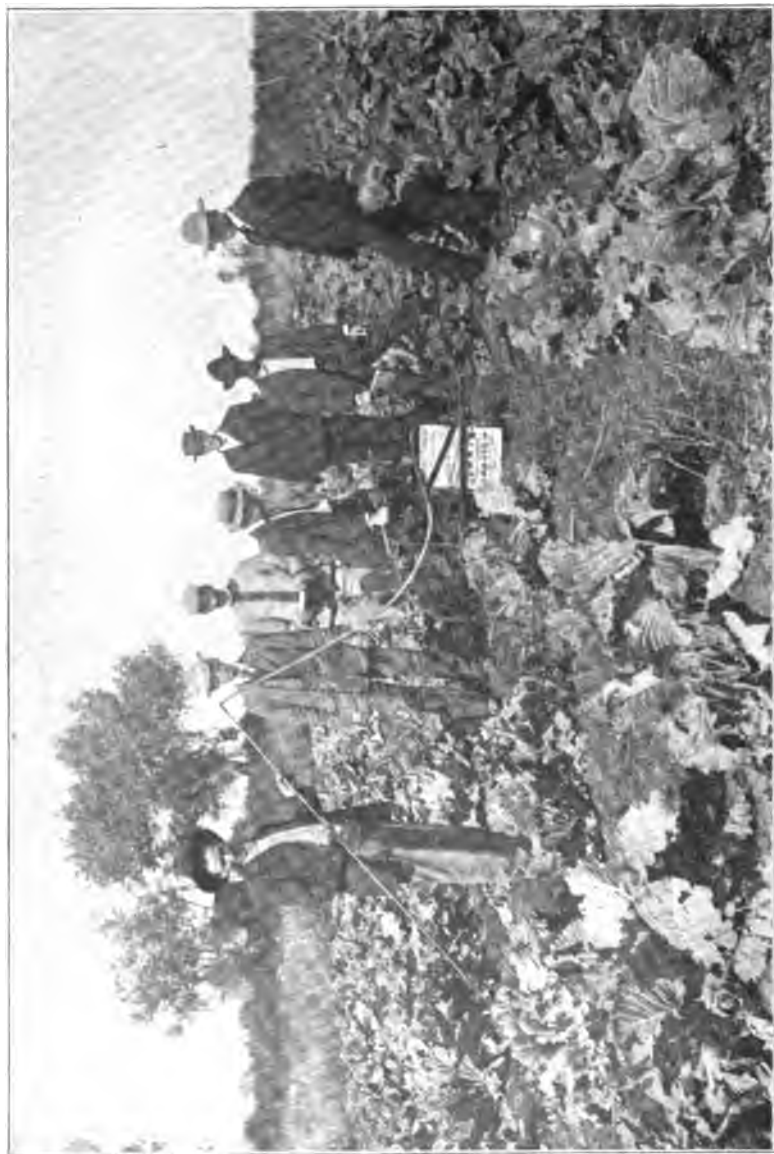


Figure 1. Spraying for the cabbage aphid with kerosene emulsion. (Original.)

well as along the fences. When the cabbage is cut, destroy all the leaves, stumps, and other refuse, as these furnish a breeding place for the aphids, many of which live through the winter in the egg or adult form. This being a sucking insect, kerosene emulsion is, perhaps, the most effective spray but cannot be used after the cabbage is heading as the taste of the kerosene would be noticed on the cabbage. Whale-oil soap solution as well as pyrethrum may be applied. The destructive work of the insect may be checked by the use of water forcibly applied through a spray pump. In order for any of these remedies to be effective prompt and often repeated action is an important requisite. Fig. 1 shows a class in Horticulture spraying late cabbage with kerosene emulsion for the cabbage aphid at Mesilla Park.

**Cabbage Worm** (*Pontia rapae*, Linn.)—The adults of this caterpillar are white butterflies tinged with very pale yellow; the male has two black spots on the wings and the female has four black spots. They appear early in the summer and lay their eggs on weeds; and the first brood of worms hatches by the time the cabbage is started. They eat holes in the leaves, and later in the heads. Owing to the fact that there are more than one brood during the season this pest is often troublesome. This worm is becoming troublesome to our cabbage growers.



Figure 2. Cabbage eaten by worms. (Original.)

**Remedies.**—As the caterpillar eats the leaves the best remedies are the arsenical sprays. If these sprays are properly mixed and applied there is no danger from the poison. It has been estimated that it would be necessary for a man to eat a dozen heads, outside leaves included, in order to get enough arsenic to poison him. The poison should be applied early enough to catch the worms before they burrow into the heads. Repeat the application at intervals if necessary. Kerosene emulsion and pyrethrum may be used but these are not so effective. Hot water at a temperature of 130° F. does not injure the plants but it will kill the worms with which it comes in contact. This remedy, while not generally used, is often recommended. The use of arsenicals is more effective when care is taken in clean cultivation. The practice of leaving all of the old cabbage plants in the fields should be discouraged.

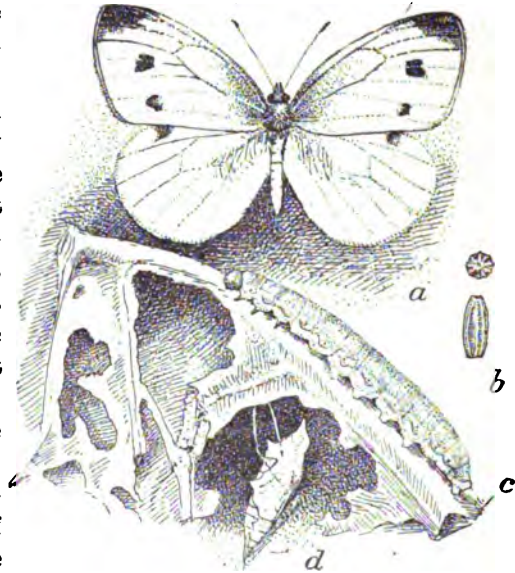


Figure 3. Cabbage worm and butterfly (*Pon-tia rapae*); a, Female; b, egg; c, worm eating on cabbage leaf; d, suspended chrysalis; a, c and d, slightly enlarged (Chittenden, Cir. 60. B. Ent., U. S. D. A.)

**Calico, Cabbage, or Harlequin Bug** (*Murgantia histrionica*, Hahn.)—This insect is very destructive to cabbage, mustard, and other cruciferous plants. It is a southern insect and is very destructive to cabbage in Texas and other southern states. It is more or less common in the Mesilla Valley doing most of its destructive work on the summer cabbage. The insects are oval, somewhat flattened, and gaudily colored

with red, yellow, and black markings. The insects pass the

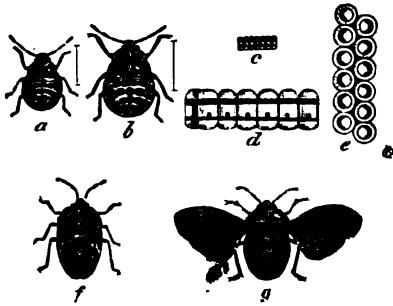


Figure 4. Cabbage bug, a, b, nymphs; c, d, egg clusters; e, egg cluster from above; f, g, adults. (Riley, Cir. 10, B. Ent., U. S. D. A.)

winter in the adult stage under any kind of rubbish. In the early spring they appear, laying their eggs and attacking the first cruciferous plants they can find. When the cabbage plants are started the insects will migrate to them. The eggs, which are laid in rows, are whitish and very small and barrel shaped, with more or

less black markings. The eggs hatch in about four days, and the entire life cycle of the insect is completed in two or three weeks, thus making several broods possible during the season.

**Remedies.**—This is a sucking insect and should be destroyed with such spray as the kerosene emulsion, but it is so tough that this insecticide is not effective on the adults. At the station the ordinary strength solution was used without killing any of the matured insects. Pure kerosene was then used which killed the bugs, but it was too strong for the cabbage plants. In this connection Professor Albert F. Conradi of the Texas Experiment Station has the following to say.\*

"The pest is difficult to destroy with insecticides, as the sprays must be made so strong that they generally injure the plants. During the last two seasons a number of experiments were conducted, using kerosene emulsion and whale-oil soap. A 10 percent kerosene emulsion, also whale-oil soap at the rate of 2 pounds to 4 gallons of water, were effective in killing nymphs. A nymph newly molted was almost invariably killed by the sprays, while an older one was as difficult to kill as an adult."

The nymph or immature cabbage bug is not as tough as the older ones. Therefore, the insect should be attacked during the nymph stage.

\*Bulletin No. 89, Texas Experiment Station, p. 11.

Clean culture and trap plants will probably be better than the sprays. Since the insects pass their winter in or near cabbage fields all the weeds and other rubbish on and about the field should be destroyed and in doing this a great many of the wintering insects will be killed. The bugs seem to have a special liking for mustard so it is recommended to plant this crop among the cabbage. The mustard may be planted a little in advance of the cabbage. When the bugs collect on the mustard they can be sprayed with pure kerosene which will kill them. Radishes are also a good trap crop. It is very important to destroy as many as possible of the early brood.

**Colorado Potato Beetle** (*Leptinotarsa decemlineata*, Say.)—Wherever potatoes are grown the common potato beetle is, or is likely to be, troublesome. The adult is of a robust and oval form, reddish yellow with 10 black stripes on the wing covers. The beetles spend the winter under ground as adults or pupae. In the early spring they appear and lay masses of yellowish eggs usually on the under side of the leaves. The larvae which hatch in a week or so, are soft slimy red colored "bugs." The entire life cycle may be a month or



Figure 5. Colorado potato beetle aa, eggs; bb, larvae; c, pupa; dd, beetles; e, wing cover. All enlarged, (Riley, Cir. 87, B. Ent. U. S. D. A.)

more and the insect is credited with having two broods and some times a partial third. Both the larvae and beetles are equally destructive and may be found on practically all the solanaceous plants such as tomato, tobacco, and chile (peppers.)

**Remedies.**—The Colorado potato beetle is a chewing insect and the free use of Paris green and arsenate of lead will prove more effective than any other spray. In small patches the beetles can be easily picked by hand. The larvae and beetles are sometimes gathered in pans and buckets containing a little water and kerosene. Clean culture and the co-operation of other growers in keeping down wild plants on which the insects feed are to be recommended.

**Corn Ear Worm or Bo Worm** (*Heliothis obsoleta*, Haw.)—This insect is quite destructive in its larval stage throughout the country. It attacks the ear of corn, especially the sweet corns, the cotton boll, tomato fruit, and sometimes the pods of beans and peas. Its greatest fondness in New Mexico seems to be for sweet corn, for which reason it is almost impossible to get any perfect ears of early corn in the gardens. The worm which varies in colors of green, purple, and pink is the larva of an ocher yellow moth marked with black. It is claimed that there are two or three generations per year.

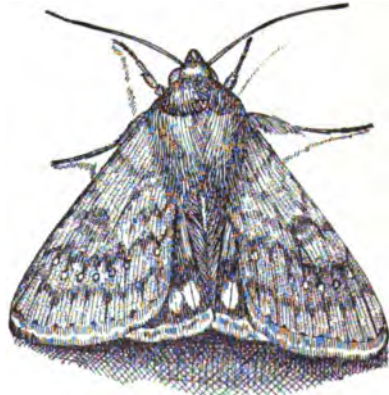
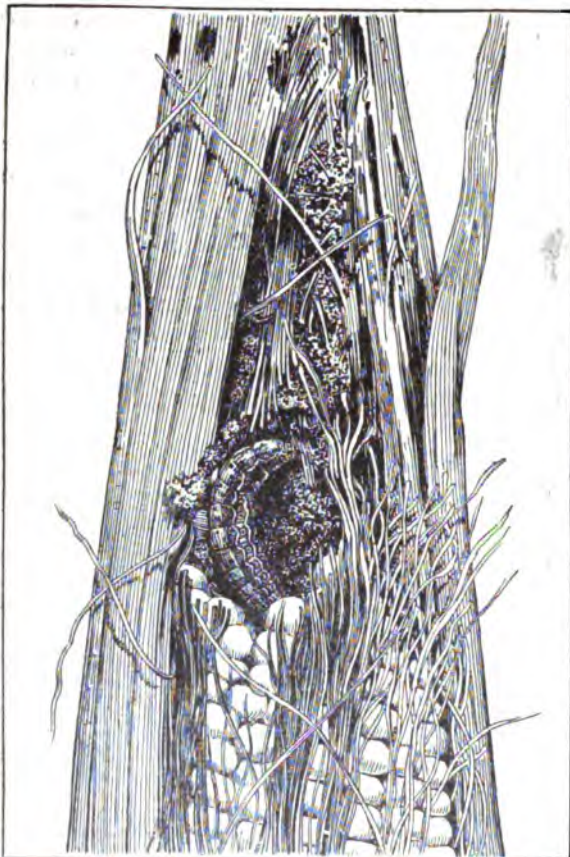


Figure 6. Moth which produces the corn ear worm. (Quaintance, F. B. 191, B. Ent., U. S. D. A.)

**Remedies.**—Owing to the fact that the insect is protected



by the husk when eating on the ear of corn, it is impracticable to directly apply any of the arsenical sprays. Some of the best practical means of combating the pest at present are the farming methods of fall and winter plowing and the judicious rotation of crops.

**Cucumber beetle (striped)**  
(*Diabrotica vittata*, Fab.)—

This beetle is yellow with longitudinal

Figure 7. Corn worm eating on ear of corn. (Quaintance, F. B. 191, B. Ent., U. S. D. A.)

black stripes and a black head and is about 2.5 of an inch long. The eggs which may be laid on almost any part of the plant or in the soil near the base of the plant, are small yellow or orange colored slightly oval oblong objects. The larva is whitish, slender, worm-like in shape and is quite destructive to the roots of its host plants.



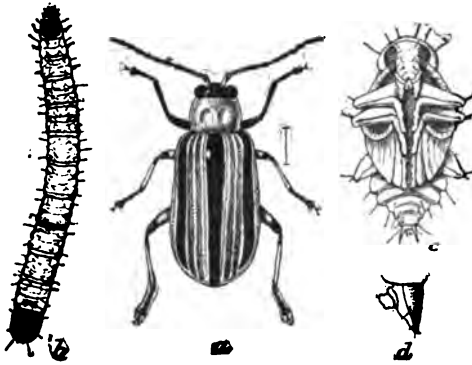


Figure 8. Striped cucumber beetle. (*Diabrotica vittata*.) a, beetle; b, larva; c, pupa; (Chittenden, Cir. 31, B. of Ent., U. S. D. A.)

In about four weeks the larva becomes a pupa and in a little over a week the adult emerges. In our mild climate several broods may develop during the season. The beetles winter as adults in the ground, weeds or other rubbish. In the early spring the hibernated beetles are likely to

become very destructive to young and tender cucumber, melon, and squash plants before they have had time to get well started. In the Mesilla Valley the striped cucumber beetle has made its appearance and some melon growers are beginning to be troubled with it. Melon growers should keep an eye on this beetle and be prepared to combat it in the spring when the plants are coming up, in case it becomes troublesome. Older plants are also injured by the beetles eating the leaves and gnawing the bark of the stems and some times the fruit.

**Remedies.**—The question of how to control this pest is a difficult one to answer. As the beetles are chewing insects, poison will destroy many of them. When they become abundant other measures such as preventives, repellents, and farm practices must be employed. As there are several methods for combating this insect the following are recommended by Dr. F. H. Chittenden.\*

"There is no specific remedy for the striped cucumber beetle. Direct application of poisons, such as Paris green or other arsenicals, will destroy the beetles when they occur in moderate numbers. Arsenicals are used alone or mixed with finely sifted plaster or similar diluent in the proportion of 1 to 75 by weight, dusted over the young plants. Pyrethrum applied with a power bellows is too expensive for general use, but is valuable in small gardens. It is applied early in the

\*Farmer's Bulletin No 254, U. S. D. A.

morning when the dew is on. Owing to the inefficiency of topical applications when the insects are most abundant, recourse must be had to preventives and repellents and cultural methods.

**Covering Young Plants.**—To prevent injury to young plants various coverings are used. A cheap frame may be made by cutting a barrel hoop in two, so as to form two semicircles, which are then placed at right angles to each other, and the ends inserted in the ground with the curve uppermost. Two strong wires bent in the form of croquet arches can also be used. The frame is covered with gauze or similar material, held in place with earth packed about the edge, to prevent the beetles working under it. It is necessary to keep the plants covered only while they are young, and the same covering may be used year after year.

**Early Planting, etc.**—Where no covering is used it is advisable to start the plants in frames or hot house, or to plant the earliest varieties and set them out as soon as possible, so as to get them well established before the beetles appear. In combination with this, the setting of late varieties should be postponed until the first appearing beetles have laid their eggs and dispersed.

**Planting an Excess of Seed.**—A certain degree of relief can be obtained by planting an excess of seed. After the first danger is passed the hills can be thinned out to the desired number. As long as the insects are seen they are poisoned with an arsenical, and this is continued until a stand of plants is obtained.

**Clean Culture and Trap Plants.**—Much injury may be prevented by attention to clean methods of cultivation. As soon as the crop is harvested the vines should be covered with straw or other inflammable material and burned. A few plants left standing about the fields will attract such insects as may not have been reached by the fire, where they can be easily destroyed by a spray of strong kerosene emulsion or Paris green. As traps for the last generation, plant later or use later varieties. By destroying the beetles at this time the numbers for the ensuing year will be greatly diminished.

Some exemption from injury may be obtained by planting beans in alternate rows before the cucumbers. Gourds planted in the vicinity of other cucurbits are claimed to act successfully as a trap.

**Driving with Air-slacked Lime.**—In some melon and squash growing sections "driving" is resorted to as a means of controlling this insect. In the morning when the beetles are active air-slacked lime is dusted over the plants with the wind, and the beetles fly before it to the next patch, where similar methods are employed.

**Arsenicals, with Ashes, Dust or Plaster.**—A remedy frequently advised is to dust the majority of the plants with sifted wood ashes, road dust, or land plaster, and cover the remainder with an arsenical. The

beetles congregate on the clean plants, where they are killed by the poison, not always, however, before they have fed to such an extent that the plants will be more or less damaged.

**Repellents.**—Land plaster or gypsum thoroughly saturated with kerosene or turpentine acts as a repellent. The vapor of turpentine is reported to be particularly distasteful to this insect. Tobacco dust sprinkled on the hills, particularly when the soil is moist, has the advantage of being, like turpentine and plaster, a good repellent, and acts as a fertilizer and mulch for the plant.

Direct remedies must be repeatedly applied, particularly when rainfall necessitates their renewal, until the plants have obtained a good start or the insects have dispersed.

A considerable degree of exemption from injury accrues from the stimulation of a crop by heavy manuring and frequent cultivation. Fertilizers should be productive of the same results.

With the exercise of good judgment in planting and combined efforts among growers of cucurbits over a considerable tract of country in the use of such of the above mentioned remedies as may be preferred the total damage from the striped cucumber beetle should be greatly lessened."

**Cucumber Beetle, Spotted, (*Diabrotica 12 punctata*, Oliv.)**—This beetle resembles the striped one but can be easily distinguished by twelve black spots on the wing covers in place of the three stripes of the *D. vittata*. The two insects are often found working together on the same plants. While occasionally this beetle does considerable injury to cucumbers and melons, the larva is credited with being very destructive to the roots of corn in the South. Last fall and winter this beetle was observed on spinach plants and it caused a great deal of trouble to one of the Mesilla Valley spinach growers.

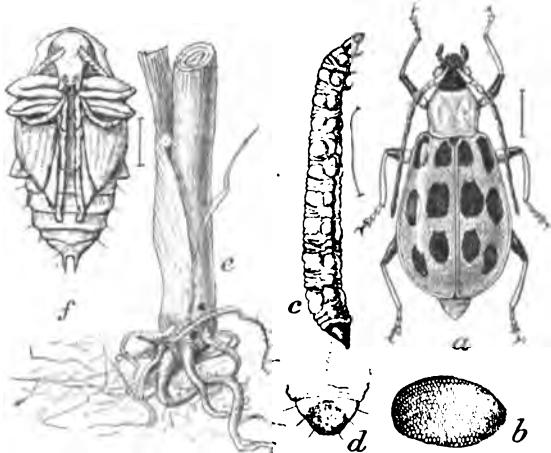


Figure 9. Spotted cucumber beetle (*Diabrotica 12-punctata*) a, beetle; b, egg; c, larva; d, pupa. (Riley & Chittenden Cir. 59, B. Ent., U. S. D. A.)

ers. On several occasions the writer has found large numbers of these beetles on and around the roots of chrysanthemums in the fall. Whenever this insect is found on the cucumbers, melons, and other cucurbits the remedies recommended for the striped cucumber beetle should be used.

**Ladybird** (*Epilachna corrupta*, Muls.)—The beetles belonging to the ladybird family are quite common in this section. They are small oval or hemispherical in shape and are red and brown with black spots or black with red or yellow spots. These beetles are divided roughly into two classes, beneficial and injurious. The beneficial species feed on plant lice and scale insects. The ladybird (*Epilachna corrupta*) is troublesome throughout New Mexico and occasionally it becomes very injurious especially to the bean crop. This beetle devours all parts of the bean plant in both the larval and adult stages. The yellowish brown eggs are laid in clusters on the under surface of the leaves. (Figure 10, d.)

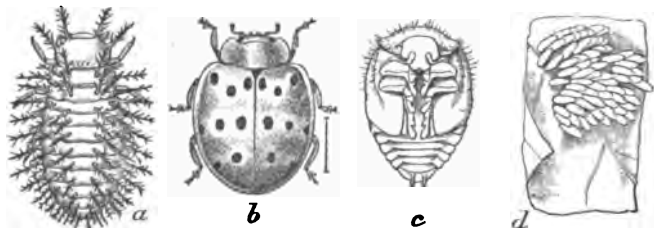


Figure 10. Bean ladybird, *chinche del frijol*, (*Epilachna corrupta*.) a, larva; b, beetle; c, pupa; d, eggs. (Chittenden, Year book for 1898, U. S. D. A.)

The larva has a yellow color and is covered with ugly branched spines. The matured beetle is light yellowish brown with eight black spots on each wing cover. This beetle is the one locally known as *La chinche del frijol* by the Mexican bean growers. The insect winters over in the adult stage and so far as it is known there is but one brood a year. It seems that in New Mexico the wintered over beetles appear about the last of June to the middle of July and the generation from these is developed in August and September.

**Remedies.**—By judiciously using Paris green and arsenate

of lead many of the larvae and adults can be killed. Greater care should be taken when using Paris green, since it is liable to injure the foliage. Kerosene emulsion is sometimes used with quite a degree of satisfaction. In small gardens hand picking of the first beetles in the summer and destroying the eggs may aid considerably in reducing the number of the late brood. Clean culture, as destroying all weeds and rubbish in the field, fall plowing, and harrowing would undoubtedly reduce the number of adults that will winter over. As there seems to be but one brood and this is most troublesome to the late crop the injury could be materially reduced by planting the beans as early as possible.

**Melon Aphis** (*Aphis gossypii*, Glov.)—This louse is one of the worst enemies the melon vine has, and the injury is done by piercing the vine and sapping its vitality. This small, inconspicuous insect is dark green and is first noticed more on account of its work. Shortly after a vine becomes infested the insects increase to large numbers and they secrete a sticky secretion often called honey dew.

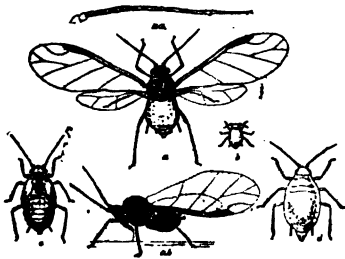


Figure 11. Melon aphid or louse. a, winged female; b, young nymph; c, last stage of nymph; d, wingless female. (Chittenden, Cir. 80, B. of Ent., U. S. D. A.)

The leaves of the vines thus infested soon begin to curl, shrivel, and darken as though soot had been dusted on them. This blackening of the leaves and stem is one of the unmistakable signs of the presence of the aphid, though by this time the destruction of the insect has gone too far to

check it with any degree of satisfaction. The aphid first attacks the melon leaves on the under side and for this reason it is a difficult thing to spray for them. In this connection Sanborn,\* specialist in Aphidae, describes the method of attack as follows:

\*Sanborn, Texas Bul. No. 89, p. 44.

"The first form which appears in melon fields locates itself on the ventral side of the leaves. This is a female. She produces young, not by laying eggs, but by giving birth to about four or ten each day. She may remain on the ventral side of a single leaf for two or three days or she may migrate from one leaf to another, and thus establish small colonies on many vines during her existence, which is about one month.

Each young inserts the setae of its beak into the tissue of the leaf and often remains at the same place until it attains the adult stage, which in this instance is usually without wings. This requires about six days. Young are then produced by this form usually on the same leaf on which it was born. In two weeks from the visitation of a migratory form and the birth of one young, a colony of about fifty can be established on one leaf. On account of a loss of nourishment on the one side while the leaf is growing, it begins to curl. If it is immature while the colony is developing, its lateral margins will grow toward each other and finally form an enclosure for the protection of the aphids.

At the age of six days each individual has attained its growth, and if the leaf on which it was born is becoming non-succulent it may crawl away from it and establish itself on a younger and more succulent one. This method of establishing themselves brings great numbers to the terminal buds of the vines, which retards the growth by corrugating all the younger leaves.

Some of the young of these generations generally acquire wings and fly to other vines and establish colonies. Consequently strict attention must be given to the vines, and if infestation occurs and no parasites can be found to exterminate it, they must at once be treated, before it is too late to be effectual."

*Remedies.*—There are many ways of combating the melon aphid, and perhaps it will be well to mention all of these so that the melon grower who is troubled with the aphids may try part or all of them. Sanborn recommended the use of rape as a trap crop for Texas conditions. This crop may also be worthy of trial by the New Mexico melon growers in case a trap crop has to be planted.

"The chief basis of operation is a trap crop for the retention of inimical insects. Rape, such as often sown for hog pasture, is the best crop for this purpose.... Besides being hardy, it is a natural food plant of an aphid, which has a universal distribution. This insect (*Aphis brassicae* L.) furnishes in itself food material for the majority of the parasitical and predatory insects which destroy aphids in general.

After this plant attains a height of three or four inches, or has three or four leaves, it generally becomes naturally infested with aphids. If infestation fails to occur, care should be taken to colonize the field artificially. This can be done by cutting a dozen or more infested cabbage leaves from your own or your neighbor's garden and scattering them in the rape field. As soon as the field is thoroughly infested, inimical insects, such as Coccinellids or ladybird beetles, also internal parasites, should be present..

If the trap crop is properly planted, it will remain in a condition to sustain insect life until after cantaloupes are ripe, or other truck has passed the stage of being damaged by aphids. Furthermore, there will have been enough inimical insects migrating from the rape field to exterminate all other aphids in proximity to the trap crop....

The manager must exercise his own judgment in regard to where in his field a trap crop can be planted to the most advantage....

The chief thing of which one must take advantage is to plant the trap crop on the margin of the field, or placed in the field which is likely to be the most foul with weeds and debris when cool weather begins, because it is in such places that the predaceous insects hibernate. Rotten or hollow logs, with loose bark, furnish some of the best natural hibernating places for these insects that can be had, and since it is essential to have as many inimical insects as possible with good hibernating quarters....

All truck farms, orchards or plantations should contain a proportionately large patch or two of rape. Before one crop of this matures another should be planted or sown, so that the inimical enemies may have an infested field in which to breed." ...

Infested vines are also rid of the insects by fumigating them.

The following method is given for Texas.\*

"For vines two or three feet long, a light frame four feet wide and six feet long, supported by legs eight inches long, is a convenient size. Lumber three fourths of an inch thick and two inches wide is suitable. Construct a frame, and nail an eight-inch leg to each corner. For frames six feet long or longer, strengthen by connecting the ends with a crosspiece. Two diagonals should be used for strengthening the frame, and also for convenience in handling, but one of the latter should not be attached until the cloth cover is in position. The latter may be made of 7 cent or 8 cent muslin, or a cheaper grade, which is not so porous as to allow a passage of gas after being oiled.

The size of the cloth should be prepared two feet wider and two feet

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\*Sanborn, Texas Bul. No. 89. P. 44.

longer than the frame which is to be covered. This is sufficient for an eight-inch wall and a four-inch lap to the ground. On the latter, dirt may be placed to keep the gas from escaping.

After the cloth has been sewed and cut into the sizes desired, it should be saturated in a vessel of linseed oil, which will fill the pores. It should then be wrung out, slightly dried and placed over the frame and held in place by nailing the diagonal to the frame above the cloth. Four covers of above size may be rendered sufficiently gas-tight by the use of one gallon of linseed oil.

The number of frames to be made depends on the amount of infestation and the rapidity of the operator. In ordinary cases, about ten frames are sufficient for one man's attention....

Place the frame over the infested plant. Take one sheet of Aphid Punk or one-half sheet of Nice-Fume paper, tear same into two equal parts, light same, and put each piece in a tin oyster or similar can, which has perforations at the bottom edge, made by driving a large nail through the side, and place each can in opposite corners of the frame, but not on the vine; light according to directions. By this time many of the beneficial insects have escaped from under the cover. With a trowel or other convenient small tool place a little dirt on the border of the cloth which lies on the ground to prevent the escape of gas. The frame should remain in position long enough to suffocate all aphids under it which is usually from three to thirty minutes. One man should have enough frames to handle so that each one in succession may remain on a vine during the above time."

For the cheap muslin above recommended the regular cold frame sash oiled cloth might be substituted. It is stronger and would not have to be boiled in linseed oil.

Carbon bisulphide may be used in small fields. This has been used at the station this year. As soon as the aphids appear on the vines, the hills may be covered over with a tub or any other like receptacle and a drachm of carbon bisulphide to every cubic foot of space evaporated. Where the exact amount of carbon-sulphide can not be measured a tablespoonful may be used for an ordinary tub.\* The gas being heavier than the air will settle and so the tub should fit as tightly as possible on the ground. Care should be had not to light any matches or have any fire around when working with the carbon bisulphide as it is very inflammable. The carbon bisulphide and the cloth cover methods might

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\*Chittenden, Insects Injurious to Vegetables.



also be tried for the cabbage bug, and other insects not easily destroyed by the kerosene emulsion.

If the aphids did not feed as a rule on the underside of the leaves the kerosene emulsion, whale-oil soap, and other soap solutions would be more effective. In spraying for the melon aphid an under spray is necessary and the nozzles should be of the up-turn style. In small fields pyrethrum is also recommended to be applied to the under surface of the leaves with a powder bellows.

The injury done by this insect might be largely mitigated by clean culture followed with winter plowing. All remnants of the crops as well as all weeds and other rubbish in and around the field should be gathered in the fall and burned as these serve as hibernating places for the aphids.

This insect now occurs in greater or less numbers in several sections of New Mexico and while it has not been very serious, it is likely to become so almost any time. The melon growers from these sections should exercise vigilance over this insect and be prepared to combat it if necessary.

**Onion Thrips** (*Thrips tabaci*, Lind.)—This insect attacks cabbage, celery, melons, leek, parsley, garlic, and onions. It is quite destructive to onions in the other states and it is now being found in different parts of New Mexico. While it is not yet doing any serious damage it may in the course of time become a troublesome pest to our onion growers. The insect is pale yellow with elongated body about 1-20 of an inch in length, and has four fringed and bristled

yellowish wings. The thrips are very active and feed in colonies and their presence can be told by the onion leaves turning whitish as though ashes have been dusted upon them.

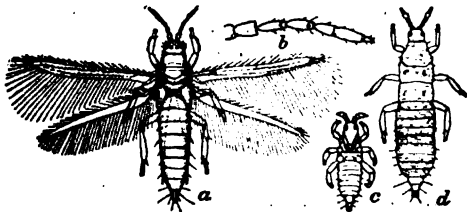


Figure 12. Onion Thrips. a, adult; c, young larva; d, full grown larva. (Howard, F. B. 120. B. of Ent., U. S. D. A.)

The eggs are laid in a slit cut in the leaf by the female. In a few days (in  $3\frac{1}{2}$  according to some entomologists) the very small nymphs hatch out. The length of the entire life cycle from the egg to the mature adult is about three weeks. The insects feed upon the plant by sapping the juices.

**Remedies.**—Contact sprays such as kerosene emulsion, whale-oil soap and rose leaf mixture are good remedies for these insects. The two last mentioned insecticides have been reported from Texas as being more effective. The whale-oil soap was used at the rate of 2 pounds to 4 gallons of water.\* The rose leaf mixture has better adhesive qualities. Some authorities say that drenching field plants with a hose will kill many of the insects. As the thrips develop on grass and weeds, all such rubbish should be destroyed.

The following letter from Chittenden gives treatment for onion thrips.

"The method of treating onion plants affected by thrips is complicated, and a full consideration of remedies is too extensive to be incorporated in a single letter.

**Insecticides.**—Kerosene emulsion, fish-oil soaps, and nicotine extracts are among the best remedies. Tobacco preparations are less effective. On account of their minute size, thrips are very difficult to reach except in their younger stages, hence remedial measures should be undertaken early in the season to act as preventive rather than a cure. Their habit of concealing themselves in flowers and other parts of plants, such as the sheaths and "boots" of onion leaves, increases the difficulties. (Information relative to the preparation and method of using the insecticides recommended are given in Bulletin 65, of the Bureau of Entomology, U. S. D. A., which, however, refers to a different species, the onion thrips being known as *Thrips tabaci*.)

**Clean methods** of field management are necessary, as the onion thrips is able to breed on many plants, feeding on most vegetables and flowering plants, and being a pest in greenhouses. It develops also on several field crops, and on weeds of various kinds. After the onion crop is gathered the useless material, such as culls, tops and injured plants, should be destroyed promptly by burning and not left where the insects can spread from them to neighboring plants to re-infest onions or other susceptible crops when they are planted the following season.

**Crop rotation.**—With an insect capable of sustaining life on such a variety of vegetation it is difficult to find an alternate crop plant that is not apt to be injured. For alternates strawberry and cucumber and other cucurbits should be avoided; also ornamental plants, roses and carnations, as all these are much favored. These plants should not even be grown in the vicinity of onion fields. Other vegetables, however, such as potato, sweet potato, beans, peas, beets, and spinach, although they may be attacked by the adults, are not as a rule materially damaged, as far as our records go."

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\*Sanborn, Texas, bulletin No. 89.

**Squash bug** (*Anasa tristis*, De G.)—This is the insect commonly known as the "stink bug," getting this name from the offensive odor it gives off when disturbed. It is about  $\frac{1}{2}$  of an inch long. The insects spend the winter in the adult stage. The hibernated bugs which are usually few in number lay their eggs on the under side of the leaves in masses. In from eight to fifteen days the eggs hatch into small greenish nymphs. At first the young bugs live in colonies near where they are hatched out. From the time the young hatch they begin to feed on the vines. The injury is one to the vine by sucking the juice the plant. The young become grown in about thirty to forty days. From one to three broods are reported from

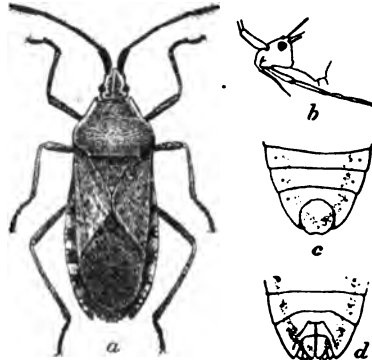


Figure 13. Squash bug, b, mature female (Chittenden, Cir. 39, B. of Ent., U. S. D. A.)

different states. The squash bug is the worst insect pest the squash and pumpkin vines have in New Mexico: cantaloupes and watermelons are injured by this insect also.

**Remedies.**—This is an exceedingly difficult insect to keep under control. As it is unusually resistant to insecticides,

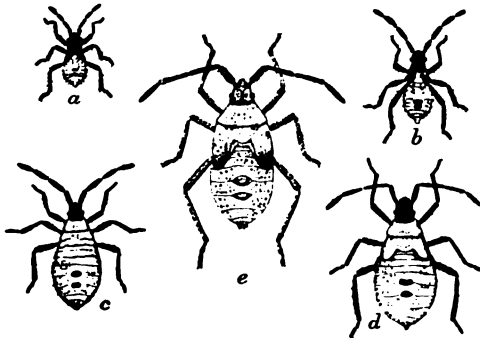


Figure 14. Squash bug nymphs. a, first stage; b, second stage; c, third stage; d, fourth stage; e, fifth stage. (Chittenden Cir. 39, B. of Ent., U. S. D. A.)

sprays strong enough to kill the adults will also injure the vines. For this reason it is necessary to practice cultural and mechanical methods of which there are a number recommended throughout the country.

Hand picking the insects is a practice followed in small gardens. In July, 1906, at the station, the hibernated squash bugs appeared on the watermelon vines and before the new generation hatched, men were set to picking the adults as well as all the leaves having eggs upon them. The insects did not bother the vines any more and it is believed that their immunity was due to this operation. This method has been practiced this year on pumpkins with satisfactory results.

The trapping of the insects by placing shingles or other boards around the vines which will attract them for shelter is another practice that is followed in some sections. The insects collected under these boards should be destroyed every morning.

Clean culture is as important in this case as with any of the other crops. As soon as the crop is harvested in the fall all vines, weeds, and rubbish in the field and along fences should be destroyed. This will reduce the chances for the late nymphs to develop into adults and at the same time reduce the number of their winter quarters. Fall plowing and disking should also be practiced.

It is claimed that the squash bugs only develop upon cucurbits,\* that other plants do not furnish food for them. This is a stronger reason for practicing clean cultural methods and destroying all vines in the fall.

A number of the measures used to keep the cucumber beetle under control are also recommended for the squash bug. Some of these are *excessive seeding, stimulating the growth of the young plant by intense cultivation, or fertilizers, use of repellents, such as lime and sulphur, and covering the young plants in the spring.* In cucumber and melon fields the damage from the squash bug may be greatly mitigated by the use of squash vines, which may be planted about a week or so earlier, between the other hills as trap plants. The squash bug, which prefers the squash vines, will congregate upon them first. The bugs may then be hand picked with great

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\* Texas Bulletin No. 89.

ease, or the infested squash vines may be sprayed with kerosene or destroyed before the bugs migrate to the melon or cucumber vines. It is to be remembered that this insect is a difficult one to control and the grower may have to use more than one method of combating it.

**The Bean Leaf Beetle** (*Cerotoma trifurcata*, Forst.)—This beetle resembles in some respects the cucumber beetle and is often mistaken for it. In color it is yellowish buff to dull red with black spots on its wing covers. The beetles when numerous do a great deal of damage to beans, peas, and other legumes as well as corn by eating large holes in the leaves. This beetle has been observed in New Mexico but it is not causing much damage as yet.

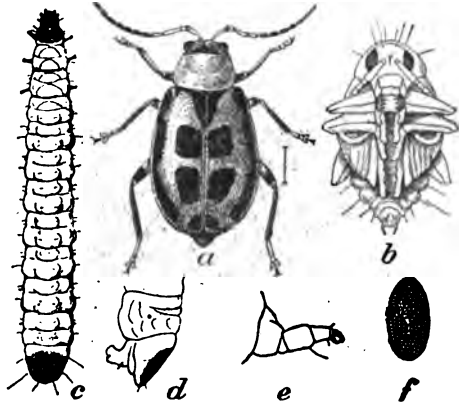


Figure 15. Bean leaf beetle. a, adult; b, pupa; c, larva; d, egg; e, egg cluster; f, egg cluster. (Chittenden, year book for 1898, U. S. D. A.)

**Remedies.**—Hand picking and the use of pyrethrum are recommended for small gardens. Clean culture is an important preventive measure. Arsenate of lead is perhaps the best arsenical spray and should be used on the first appearance of the insects.

**Tomato Worm** (*Phlegethontius quinquemaculata*, Haw. and *P. sexta*, Joh.)—The stage of life that we are most familiar with in these two insects is the larva. The caterpillars of both of these species are very large and have a horn like projection at the posterior end. Some imagine that this horn bears a poison but the larvae are absolutely harmless. While both species resemble each other very much in many respects, *P. quinquemaculata* has a larger and less curved horn and is somewhat darker in color than *P. sexta*.

The larva is characteristically marked with eight white longitudinal stripes which curve back horizontally at an angle. The pupa of this species is brown with a curved projection which is a covering for the tongue of the future moth. The moth has a wing expansion of four inches with four dull orange spots on the side of the abdomen. The moth of *P. sexta* has five brighter and larger spots. The pupa has a

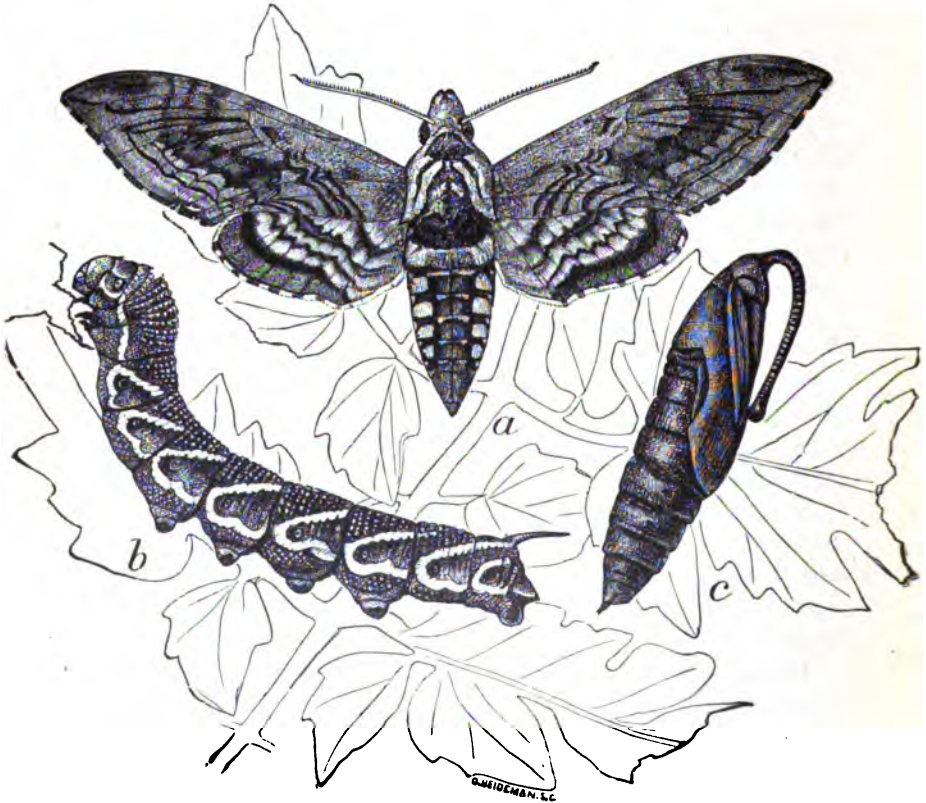


Figure 16. Tomato worm (*Phlegethontius quinque-maculata*) a, moth; b, full grown larva; c, pupa. (Howard, F. B. 120, B. of Ent., U. S. D. A.)

shorter tongue cover, and the larva has only seven oblique white stripes. The caterpillars are from 3 to 5 inches long

and about as thick as one's little finger. They are most commonly found eating the tomato, tobacco, potato, and chile plants. Both of these insects pass the winter buried in the ground in the pupa stage.

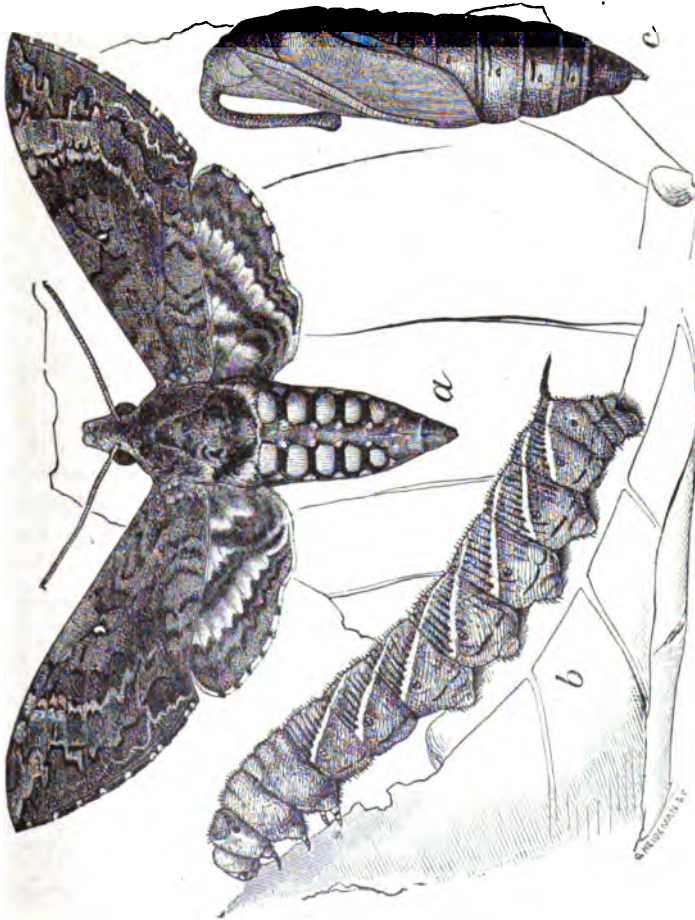


Figure — Southern Tomatoworm (*P. sexta*) a, moth; b, full grown larva; c, pupa. (Howard, F. B. 120, B. of Ent., U. S. D. A.)

**Remedies.**—Clean culture and the rotation of crops should be practiced. Liberal applications of arsenical sprays will kill the worms. Owing to the large size of the worms they

can be kept under control much more cheaply and with less trouble by handpicking them. At the station this practice has given very satisfactory results. In June, 1905, a large number of caterpillars infested small field of Irish potatoes at the station and it was necessary to go over the plants every day for about a week. After this time the caterpillars disappeared altogether. It has been observed that the best time to go over the plants is in the forenoon before the sun gets too hot. At this time they are more actively eating on the leaves and can be more easily found.

### Insects Injurious to Staple Crops

**Chinch Bug** (*Blissus leucopterus*, Say).—This insect is about 1.5 of an inch in length with a black body and white wings. The winter is passed in the adult stage in grass and other rubbish in and about the fields. In the spring they come out and lay their eggs, from which hatch small reddish bugs. The eggs are laid in the ground among the roots or on the stalks of wheat and other grain crops on which the nymphs feed. These become adults in midsummer and the eggs for the second brood are then laid. There is a great tendency for this insect to migrate and although the adults have wings they prefer to move from field to field on foot. Were it not for the fact that they move as an army it would be impossible to check them in their movement. This insect has never been re-

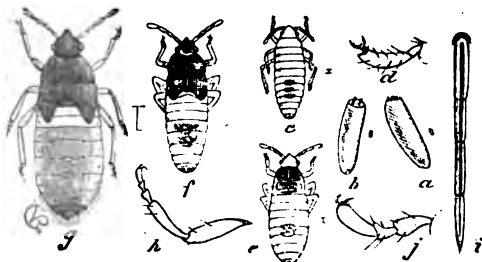


Figure 18. Chinch bug. a, b, eggs; c, e, f, g, different stages of growth of the nymph. (Riley, Cir. 9, B. of Ent., U. S. D. A.)

ported from any part of New Mexico as injuring crops, though there were very large numbers observed during the summers of 1905 and 1906 in the Mesilla Valley.

**Remedies.**—In the winter all weeds and rubbish in the field and along the fence lines should be burned and in doing this



many of the hibernating adults may be destroyed. It is during the time that the insects are moving from field to field that the best work can be done to check them. A furrow should be plowed out in the path of their march and the bottom should be pulverized to make a fine dust mulch. The bugs in trying to pass over will be unable to climb the side of the furrow as the fine dust will slide from under them. A large number of insects will accumulate in the furrow after which they may be crushed by dragging a log. Deep holes may be made in the bottom of the furrow into which large numbers of insects will fall and can then be killed. Ditches can also be filled with water having a thin film of kerosene which will kill the insects falling in. Smearing a narrow strip around the field with tar has been practiced with satisfactory results. In cases where no steps have been taken to stop the insects from entering a field the outside rows of grain may be sprayed with kerosene emulsion composed of one pound of soap, one gallon of water and two gallons of kerosene and diluted with 15 quarts of water.\*

**Fall Army Worm** (*Laphygma frugiperda*, S. & A.)—This worm, which is very similar in its habits and general appearance to the true army worm, may be identified by a yellowish stripe down the middle of the back and a longitudinal pitch colored stripe on each side. There are four black spots arranged in pairs along its back. The worm is about an inch in length and not quite as large as the true army worm. The moth lays her eggs on the grass in clusters of about 50 and these hatch in about ten days. There are two or three broods a year. The winter is passed in the pupal stage.

While the grasses and cereals form the favorite food of the army worm, it also feeds on a large variety of other cultivated plants, among which is alfalfa. In

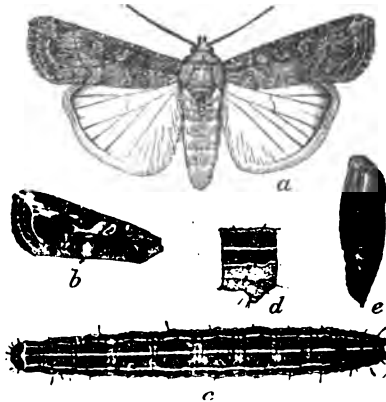


Figure 19. Fall army worm. a, moth; b, egg cluster; c, full grown worm; d, pupa; e, pupa. (Chittenden, Bulletin, 29, B. of Ent., U. S. D. A.)

\*Sanderson's—Injurious Insects to Staple Crops, p. 57.

Nebraska it is called the alfalfa worm on account of its peculiar fondness for that plant.

*Remedies.*—Since there has been no remedy tried here for the prevention or eradication of this pest, those recommended for the East might safely be tried. Clean cultural methods and the rotation of crops are emphasized by all of our authorities on the subject.

Such mechanical means as the mowing of the crop around the edges of the field and burning it are effective, since many of the worms are destroyed with the crop. The march of worms from one grain field into another can sometimes be checked to a large degree by plowing a steep ditch between them and dragging a log back and forth through the ditch, killing the worms as they crawl into the trench. It is sometimes recommended to dig holes in the bottom of the ditch every few feet. The worms, falling in these holes are not able to climb out, and they can then be more easily killed. The ditches may be filled with water and the addition of a little kerosene so as to form a scum, is enough to kill the worms which fall in. Large numbers of worms can also be destroyed by spraying with Paris green or some other poisonous mixture. This, however, must be used with great care and stock must not be allowed to pasture in fields thus sprayed. On annual crops deep plowing, thorough harrowing or rolling help very materially to destroy the hibernating worms and prevent their attack the following season.

In the case of perennial crops, such as alfalfa, fall plowing is not practical, but a thorough disking and harrowing will give practically the same results as fall plowing. Very little has been done in checking the ravages of the worms on alfalfa. However, it seems advisable and practical that when the worms appear, in large numbers, on newly cut alfalfa that the stubble be rolled with an ordinary heavy roller. In this way a very large number of worms feeding on the newly formed growth will be crushed. It is hardly practical to roll alfalfa that has made a considerable growth or that is almost ready for cutting, since the alfalfa would be crushed

- down so that it could not be mowed. In the event of the worms attacking the alfalfa in this stage of growth it would be better to cut it and haul it away, and then roll the stubble.

In 1905 in the Mesilla Valley the worms made their appearance on a number of farms about the time the first crop was being harvested; some fields were damaged more than others. No remedial measures were taken at the time. A number of the alfalfa growers who had experience with the worms are of the opinion that our hot sun, shining on the unprotected larvae, is more or less fatal to them. It was noticed by a few of the alfalfa growers that soon after the alfalfa was cut and raked a large number of the worms, which had been feeding on the alfalfa before it was cut, were found dead in the field. After the alfalfa is cut and hauled away the worms are left without any shade to find refuge in. The bare stubble of the alfalfa does not seem to afford sufficient protection to the worms from the sun. Some local alfalfa growers attribute the dying of the worms to the hot sun shining on them after the alfalfa is hauled away.

**Grasshopper** (*Melanoplus* spp.)—In New Mexico as in other states the grasshoppers do considerable damage to agricultural crops, some years more than others. This insect needs no description in this bulletin as it is well known to all. It passes the winter in the egg stage, but in the Mesilla Valley in the south central part of New Mexico many of the adults are active until very late in the winter.

The life history of the grasshopper is quite simple. In the fall the female lays her eggs in pods

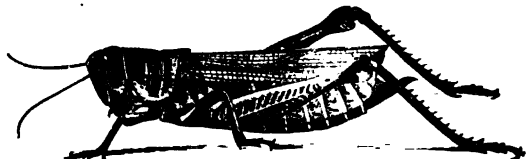


Figure 20. Grasshopper. (Riley, Clr. 84, B. of Ent., U. S. D. A.)

containing from 20 to 50 each, in holes made by herself an inch or so in depth in the soil. The pod of eggs is covered over with a glutinous material, which is waterproof. The ditch banks, grass and alfalfa fields, corners and edges of

fields afford excellent places for the female to lay her eggs. The following spring and summer the hoppers come out of the egg, and being so small at first they are not easily detected. As the nymphs become larger, they require more food so that their work on the crops soon becomes very noticeable.

*Remedies.*—There are a number of methods recommended for combating the grasshoppers that are quite practicable and if they are constantly practiced the destructive work of these insects may be materially reduced.

Winter plowing or deep disking is most effective where it is possible at all. The plow or disk disturbs the egg pods, burying some, breaking open others, and exposing still others to the sun, rain, birds, and to other enemies.

Poisoned baits are used chiefly for the crawling and jumping species. Poisoned bran, which is used quite commonly, is prepared by mixing one to two pounds of Paris green or arsenic and 20 to 50 pounds of bran together with enough water to thoroughly moisten the mass. Add one or two pounds of sugar or a little molasses, so that the bran will stick together. Distribute the poisoned bran in small balls near the plants disturbed by the grasshoppers. Care should be taken that chickens or other domestic fowls or animals do not eat the poisoned bran. A patch of young alfalfa, weeds, or some vegetable crop and also the grass and weeds surrounding the field may be sprayed as a trap crop for young nymphs.

The species that fly from tree to tree can probably be managed best, when it is safe to do it, by spraying with Paris green or arsenate of lead.

The Hopperdozer, when used freely and continuously, tends to reduce the number of grasshoppers in a field. The hopperdozer is a long, shallow pan of sheet iron, set on two runners and having behind an apron or sail of canvas stretched on an upright frame. When the machine is ready for use place some water in the bottom of the pan, add enough coal oil to form a film over the water, and hitch a

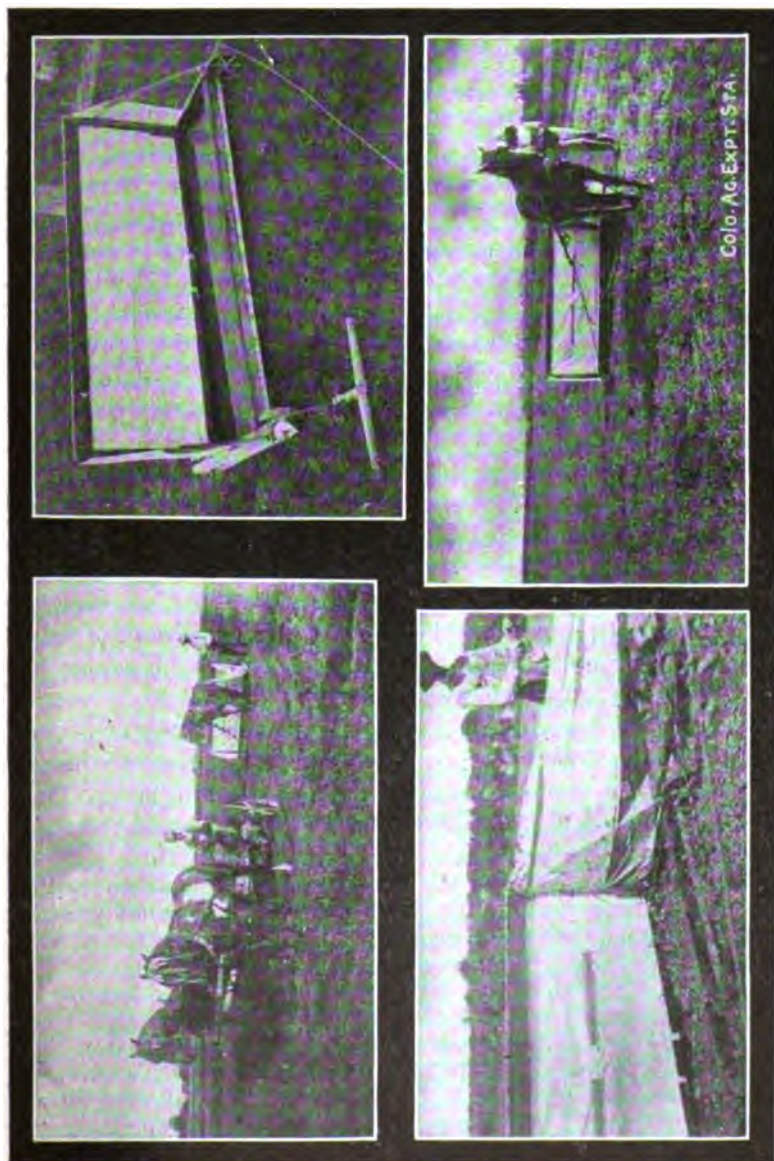


Figure 21. Hopperdozer in use in alfalfa field. (Blinn, Bulletin 112, Colorado Experiment Station).

horse to one of the outside runners, bring a long rope from the other runner and hitch it to the hame staple of the harness. As the grasshoppers fly, many of them strike the apron behind and fall back into the pan containing kerosene, which is fatal to the insects. As fast as the pan fills up with grasshoppers, remove and fill again with water and oil. These hopperdozers are better adapted for use in alfalfa fields, and still better results can be had if they are used before the grasshoppers have formed wings. Very satisfactory results are reported from Colorado by the use of hopperdozers in alfalfa fields. (See Fig. 21). In and around Albuquerque, New Mexico, alfalfa growers are using the hopperdozer with satisfactory results.

The hopperdozer at the New Mexico Experimental Station is made out of galvanized sheet iron, and is 5 feet long, 2 feet wide, and  $3\frac{1}{2}$  inches deep (the depth should be at least 5 or 6 inches) set on 2x4 inch runners 4 feet long, placed at the extreme edges of the pan. The apron or sail is  $3\frac{1}{2}$  feet high. The runners can also be placed on small wheels, which will lighten the draft and allow the pan to be drawn over the field without catching on weeds and trash. The machines may be made in any sizes and ways.

**June Beetle** (*Lachnosterna* spp.)—The June bug or June beetle is well known to all, as the brown beetle flying around the light in the room at night in the early summer. The larvae or white grubs of these beetles are sometimes found damaging the lawns in the Territory. The grubs imbed themselves in the roots of the grass and cause considerable injury by eating them. In other states corn, small grain, grass, potatoes, and other crops as well as shade trees are liable to be injured.

*Remedies.*—As far as the writer knows nothing has been done for the grubs injuring the lawns in New Mexico. In other states bisulphide of carbon and kerosene emulsion are used. The emulsion which is applied just before a rain, is diluted about ten times and poured on the ground where the grubs are at work. Gas lime used at the rate of four barrels to 100 sq. ft. of ground on the lawn has been used quite effectively.

## Fruit Insects

**Apple Tree Louse or Woolly Aphis** (*Schizoneura lanigera*, Hausm.)—This insect is getting to be quite common in New Mexico. In the Mesilla Valley a large number of the apple trees which have died have been infested with the root form. The woolly aphis is very small, about as large as a pin head. The winter is passed in the egg stage, but occasionally, in warmer climates, adult insects live through till spring. During the spring the eggs hatch into wingless agamic female forms. These bring forth living agamic females, and their offspring are produced likewise. This method of reproduction is very rapid and it accounts for the large colonies of insects found on the trees. In the fall some wingless and mouthless males and females are produced. These pair off and each female lays a single fertilized egg and then dies.

The woolly aphis affects apple trees on the limbs and roots; thus the common terms root and tree forms. The tree form, which is found in colonies on the ends of the new succulent growth and on the scars produced from pruning, can be easily recognized by the dense bluish-white cottony looking substance covering the wingless insects. While the aerial form may cause abnormal growths, or even death, of the parts infested, the injury from this form does not seem to be as yet very serious in this climate.

The root form of this insect, on removing the dirt from the roots close to the trunk of the tree, can also be easily detected by the same bluish-white cottony substance and knotty or irregular growth of the roots.

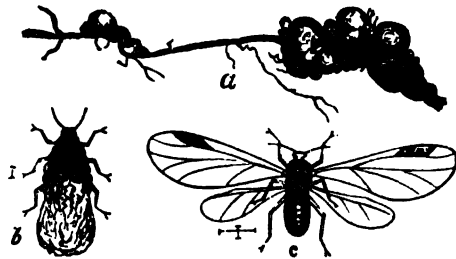


Figure 22. Root woolly aphis. a, root showing swelling caused by the aphids; b, wingless aphid with woolly secretion; c, winged aphid. (Saunders).

It is this form that causes serious trouble to our apple growers.

The woolly aphis is a sucking insect and gets its nourishment by piercing into the wood and sucking the sap therefrom. The roots affected become knotty and shortly stop performing their function properly.

*Remedies.*—The tree form of the woolly aphis will usually succumb to one or two thorough sprayings with the kerosene emulsion diluted three times. The root form is not so easily destroyed by the kerosene emulsion, though it is sometimes used for it. Two of the best remedies for the root form are tobacco dust, and carbon bisulphide. The use of the latter is advised for extreme cases only, where the trees are badly infested and it is desired to destroy the insects immediately. The carbon bisulphide is injected six or more inches by means of an injector into the soil and on opposite sides of the trees. Great care must be exercised in the use of the carbon bisulphide, as it is very injurious to both animal and plant life. Do not allow the liquid to touch either tree or root; if it does it is liable to injure them. It is also advised to inject the fluid while the soil is dry, as in wet soil the fumes from the carbon bisulphide will not be of much use.

The tobacco dust treatment is perhaps the safest and most satisfactory. From two to four inches of soil above the roots and from two to three feet around the trunk is removed. A liberal supply of tobacco dust (about five pounds for a five or six year old tree) is applied over the roots. After the tobacco is applied it should be covered and irrigated. The water will leach the nicotine out and carry it down to the roots, where it will come in contact with the insects and kill them. Lime and gas-lime are also recommended to be used like tobacco. The trees should be treated in the spring.

Professor J. M. Stedman,\* of the Missouri Experiment Station, who has had considerable experience with the woolly aphis, has the following to say about the tobacco and bisulphide treatments:

"The insects may be killed by injecting one fluid ounce of carbon bisulphide two feet away from the trunk on two sides of the tree but the use of the substance is not advised except in extreme cases, since a

\*Missouri bulletin No. 35, p. 37.



little carelessness may injure the tree. The root form of the woolly aphid may be cheaply and easily killed and kept away from an apple tree by liberal use of tobacco dust. About five or six pounds of this substance should be applied . . . to the roots of every infested tree, and one-half this amount should be applied in a similar manner each succeeding spring; costing approximately two cents per tree per year."

**Black Peach Aphid** (*Aphis persicae niger*, Er. Sm.)—The black peach aphid like the woolly aphid of the apple, affects the foliage and roots of the peach tree. The peach aphid occurs in two forms, winged and wingless, the latter affects both the roots and the foliage, while the former occurs only on the tender shoots and leaves. Both of these forms are illustrated, greatly enlarged, in figure 23.

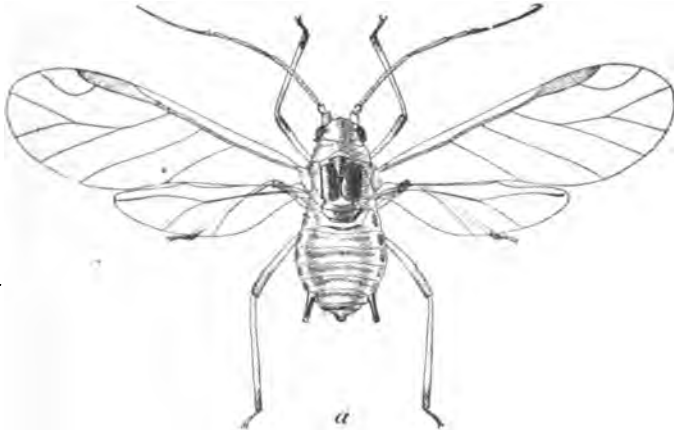
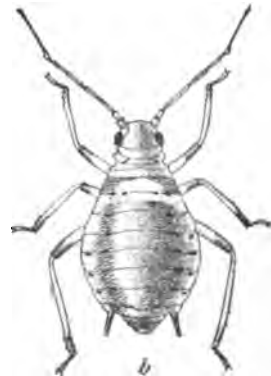


Figure 23. The Black Peach Aphid. a, winged female; b, wingless female. (Quaintance, Year Book, 1905, U. S. D. A.)

The young insect is of a faint greenish brown color, becoming darker as it gets older. When it reaches the adult stage it is black. The root form is not quite so black as the tree aphid. The insect lives on the roots of the tree during the season and breeds continuously, except during the winter when it is hibernating. In the spring the aphids appear and begin to



feed and breed on the young succulent growth. Insects of all ages may be found promiscuously together on the shoots and leaves of the infested tree. The root form is the most serious pest. Whenever the tree is badly infested the foliage has a yellowish green, sickly appearance, the leaves becomes curled at the edges and oftentimes are blotched with red suggesting the "yellows".

*Remedies.*—The tree form, like all the other tree aphids, can be checked by the use of the whale-oil and kerosene emulsion. The whale-oil soap is used at the rate of one pound to seven gallons of water, while the kerosene emulsion ought to be at the rate of 1 gallon kerosene to 5 to 7 gallons of water. The spraying should be done thoroughly, repeating it if necessary.

Where the root form of the insect has established itself on the roots of the peach tree, its control is no easy matter. The use of unleached wood ashes, kainit, or tobacco is recommended. Tobacco dust which is about the most practical remedy,\* is dug in about the tree. Speaking of the remedies for the black peach aphid A. S. Quaintance\*\* has the following to say:

"Heavy dressings of kainit, according to Dr. J. B. Smith, are effectual in killing the aphides. The fertilizer should be applied over the ground covering the root area of the tree, preferably just before a rain. Unleached wood ashes, from one-half to one bushel per tree, is recommended by Pettit as being very effective. It is better to first remove the soil over approximately the root area of the tree, replacing it after the ashes have been applied. Ground tobacco dust may be used in the same way. In all of these substances the insecticidal properties leach out, coming in contact with the soft bodies of the aphids on the roots and thus killing many of them.

Mr. H. G. Welch, of Douglas, Mich., reports much success from the free use of stable manure applied around the trees, which are thus enabled to outgrow the effect of the aphides. In general, it would seem that injuries from the pest would be overcome to a considerable extent by supplying the tree with an abundance of plant food in the way of fertilizers and by cultivation. Prof. Wesley Webb, of Delaware, reports success in the control of this pest in nurseries in the sandy soils of that State by the free use of tobacco dust as a fertilizer, drilled in with the seed, or later along the rows of the trees."

**Canker Worms** (*Anisopteryx pometaria*, Harris and *Paleacrita vernata*, Peck.)—These are two distinct species but their

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\*Michigan Bulletin No. 24, p. 55.

\*\*Year Book for 1905, p. 343.

habits and characters are so similar that they can be treated together here. They are commonly known as the fall canker worm and the spring canker worm, taking their names from the time they appear. In both of these species the sexes are unlike, the males have wings while the females are wingless. The caterpillars of both species when full grown descend to the ground to pupate. When the wingless females emerge either in the fall or in the spring they crawl up the trunks of the trees, and lay their eggs on the twigs or leaves. The



Figure 24. Fall canker worm. a, male moth; b, female moth. (Riley, B. of Ent., U. S. D. A.)

The caterpillars of both species are very similar, being of a more or less variable olive green color and about an inch long when fully grown. These caterpillars feed upon the

tender leaves of apple trees, oftentimes defoliating them. These insects if present in New Mexico are not doing any damage as yet.

**Remedies.**—As the females are wingless and have to crawl up the trunks of the trees to lay their eggs on the twigs and leaves, rope, cloth or paper bands smeared with printer's ink, coal tar, pine tar, sorghum molasses, or any other sticky material that will prevent the ascent of the moths and hold them fast may be used. These bands may be about six inches wide and tied in the middle. The smeared bands must be renewed every once in a while to keep them sticky. Tin and rubber troughs with oil have also been used with some success. Care must be taken to fill up all of the irregularities in the trees so that the moths will not be able

eggs laid by the moths of the fall hatch about the same time that those laid in the early spring by the spring canker worm moths do.\*



Figure 25. Spring canker worm. a, male moth; b, female moth. (Riley, B. of Ent., U. S. D. A.)

\*Saunderson—Insects Injurious to Fruits

to crawl through underneath the band or trough. If the moths are not prevented from crawling up the trees and the trees become infested with the caterpillars the spray pump with an arsenical mixture must be used to kill the worms.

**Codling Moth** (*Carpocapsa pomonella*, Linn.)—This is the worst insect pest the apple grower has in New Mexico. Some work has been done in spraying for the codling moth at the station and the results have been encouraging. The study of its life history has also been taken up and already some results on this subject have been published. The overlapping of the broods and the marked irregularity in the appearance in the daily number of larvae is very noticeable. Paris green and white arsenic were the poisons used at first but arsenate of lead which seems to be superior has taken their place.

For a detailed discussion of the codling moth question in New Mexico the reader is referred to New Mexico bulletins Nos. 25, 41, and 65. During the spring of 1907 an experiment to starve out the codling moth was begun. This work was made possible by the late and severe freeze of April 21st which practically destroyed all the fruit in the Mesilla Valley. The few apples in the Valley that escaped the freeze were pulled off the trees and destroyed by men who were placed in charge of that work.

**Cottony Maple Scale** (*Pulvinaria innumerabilis*, Rathvon.)—This insect has been reported from Las Vegas and Raton as injuring the maple trees there. In other states it is sometimes found on grape vines and Virginia creepers.

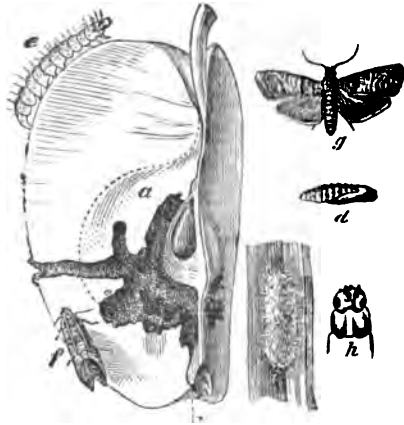


Figure 26. Codling moth. a, burrow in apple; d, pupa; e, large worm; f, moth with wings closed; g, moth with wings open; i, cocoon. (Kiley. B. of Ent., U. S. D. A.)

These insects are soft bodied and more or less brown in color. When full grown they are somewhat irregular in outline and approximately a quarter of an inch long. They are protected to some extent by a fluffy cotton like mass. Small crawling larvae hatch from eggs laid in the late spring or early summer. These young larvae move about upon the leaves and twigs where they feed.

**Remedies.**—This being a sucking insect the kerosene emulsion and other soap solutions are the ones used. Winter and early spring spraying with a 20% strength kerosene emulsion is claimed to be very effective. Ordinary spraying of kerosene emulsion and whale oil soap will destroy the young aphids during the summer.\*

**Fall Web Worm (*Hyphantria cunea*, Dru.)**—The moth producing this caterpillar is white and sometimes has a few black spots on the wings. The larvae hatching from masses of eggs laid on different parts of the trees spin their webs which extend over quite an area. These webs may be noticed in the Mesilla Valley by the middle of July on a number of trees but more particularly on the cottonwood and poplar. The caterpillars will first eat all the leaves within the web, then those nearest by, often defoliating the entire tree. The worm is noticeably set

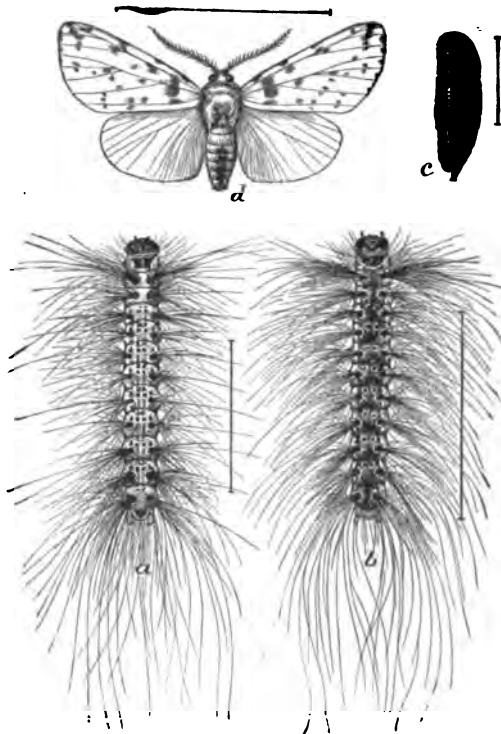


Figure 27. Fall web-worm. a, b, caterpillars; c, pupa; d, moth. (Howard, year-book, 1895, B. of Ent., U. S. D. A.)

\*Gillette—Colorado bul. 114—p. 22.

Two broods are reported, the last one seems to be the worst. This insect is sometimes confused with the tent caterpillar which appears in the spring and builds its webs in the forks of the limbs.

**Remedies.**—The clusters of eggs on the limbs should be destroyed if possible when the leaves are off. The webs or tents may be cut out and destroyed or they may be burned with a torch. If this cannot be done spray with standard solutions of some of the arsenical mixtures.

**San Jose Scale** (*Aspidiotus perniciosus*, Comst.)—This insect is very small in size, being about 1-16 of an inch in diameter and inconspicuous in color. As the scale multiply in number the parts of the tree infested become practically covered with the insects, giving them the appearance of a grayish scurvy deposit on the bark. If these badly infested limbs are rubbed over with the thumb nail or some object many of the insects will be crushed underneath the protecting scales and a moist and oily appearance will be produced; while others will be overturned and the small yellowish, soft bodied insects revealed.

The mature insects are nearly circular in form and each is slightly raised in the center forming a nipple-like elevation which is lighter in color than the rest of the scale. There are several concentric circles between the outside edge of the scale and

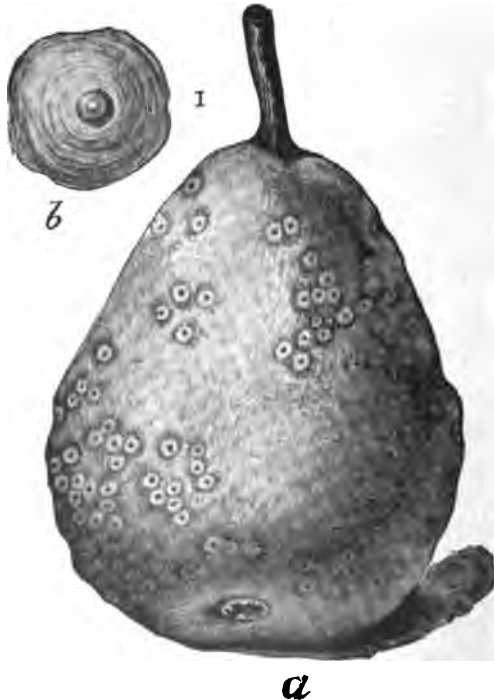


Figure 23. San Jose Scale on a pear; b, scale enlarged. (Howard, Cir. 3, B. of Ent., U. S. D. A.)

the nipple in the center. If the scale is carefully raised with a sharp pointed knife the yellowish insect itself can be seen attached to the bark of the limb.

Many of the insects perish during the winter but each female of the over-wintering generation is capable, under favorable conditions, of producing about 100 young. So, realizing the rapidity with which these insects increase, it is not surprising that even a few active females in the spring may completely reinfest the tree. Here then, lies the great

importance of thoroughly spraying the trees during the winter or spring. Every insect should be destroyed or else the tree is likely to be reinfested during the season.

The San José scale when very abundant kills the trees and also attacks the fruit, causing small circular reddish blotches wherever it attaches itself to the apple or pear. In the early stages of infestation a few scales may be found, usually about the rings and rougher parts



Figure 29. San Jose scale on a pear branch. (Howard, Cir. 3, B. of Ent., U. S. D. A.)

of the limbs or in the crotches of the trees. The infested apple trees in the Mesilla Valley that the writer has inspected during the past winter have practically all of the scales on the lower parts of the main trunk and larger lower limbs. The younger and newer growth toward the ends of the limbs shows very few, if any, of the insects. A large number of the insects found on these trees in the spring are dead. Although the San José scale has been known in the Mesilla Valley for about 15 years, it does not seem to spread much, nor has it been a very serious pest.

*Remedies.*—The insect belongs to the sucking kind, which

must be killed by contact sprays. Many of these sprays have been used from time to time with good results but the one now universally used is the "lime sulphur" spray. The materials used in the preparation of this spray are good unslaked stone lime, flowers of sulphur, and water.

The results of the more recent investigations in other states show that the lime and sulphur wash, without salt, has been practically as efficient as with the salt added to it. The salt can be added to the mixture if one wishes to do so, but it does not seem to be necessary. This spray was used last winter at this station with satisfactory results.

**The Apple Tree Tent Caterpillar** (*Clisiocampa Americana*, Harris.)—This insect is found in many states but as yet it has not been reported in the Territory. The larva is troublesome to apple trees. It builds its nests or tents in the forks of the tree in the spring and from there moves out on the branches and eats upon the leaves. The caterpillars come out of their nests to feed during the warmer part of the day. The winter is passed in the egg stage.

The eggs are deposited close together about the twigs.

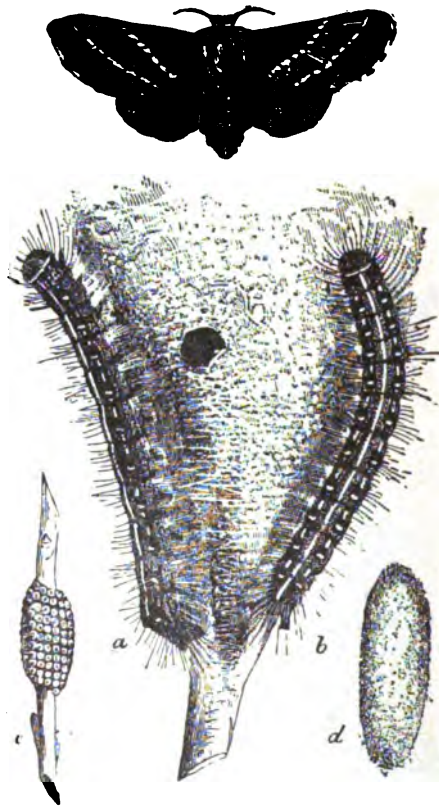


Figure 30. Apple tree tent caterpillar. a, b, caterpillars; d, cocoon; c, egg mass. (Riley, B. of Ent., U. S. D. A.)



**Remedies.**—The twigs containing the egg masses may be destroyed during the winter. The conspicuous nests or tents should be burned or destroyed while the caterpillars are inside of them. Spraying the trees with arsenical mixtures is effective. This caterpillar and fall web-worm may be treated alike.

**The Apple Twig Borer** (*Amphicerus bicaudatus*, Say.)—This insect has been reported from Roswell, New Mexico, as boring into the twigs of small apple trees. It attacks apples, pears, cherries, and other trees, and bores into the twig just above a bud for food and shelter. The beetle which does the damage is about  $\frac{1}{8}$  of an inch long, cylindrical in form, brownish above and black underneath.

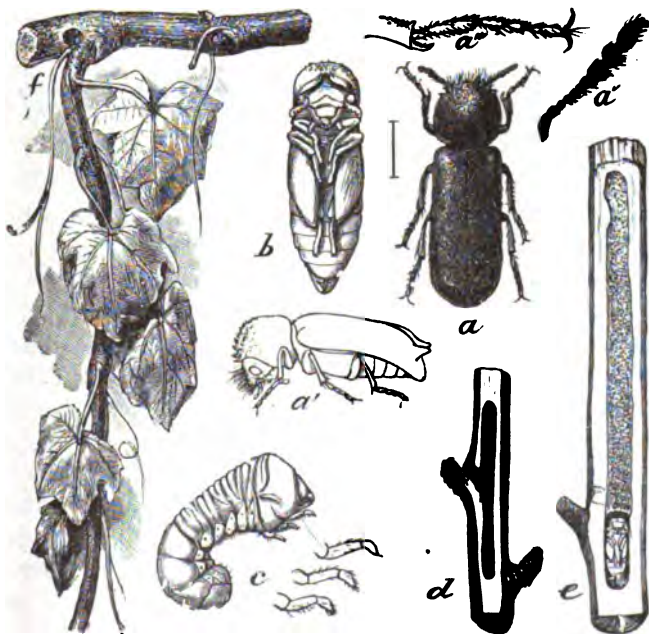


Figure 31. Apple Twig borer. a, a, two views of beetle; b, pupa; c, larva; d, e, f, twig burrows. (Marlatt, F. B. 70, B. of Ent., U. S. D. A.)

**Remedies.**—The remedy that is recommended is to look for the infested twigs, cut them off and burn them.

**The Flat-Headed Apple Tree Borer** (*Chrysobothris femorata*, Fabr.)—The beetle which produces this borer is about one half inch in length and flattish oblong. It has a dark shining green color and the same colored feet. The eggs, which are yellow and very small, are laid by the female under the loose scales or within the cracks of the bark. The mature larva which is pale yellow and legless, has the head and thorax very much enlarged and flattened. The larva makes irregular channels in the sap wood in which it remains till shortly before pupation time, when it bores deeper into the solid wood. The larva stage is claimed to be from one to three years. These borers attack pear, peach, and apple trees.

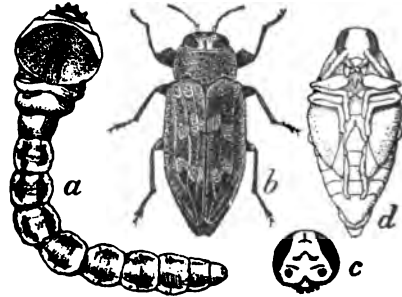


Figure 32. Flat-Headed Apple tree borer. a, larva; b, beetle; c, pupa. (Chittenden, Cir. 32, B. of Ent., U. S. D. A.)

**Remedies.**—The most effective remedy is to dig the borers out with a pocket knife or some other sharp pointed instrument before they are too deep within the tree. The presence of the larvae may be detected by the discoloration of the bark or a slight exudation of sap or small amounts of sawdust castings on the tree. Whitewashing the tree is said to prevent the laying of the eggs. Soft soap and washing soda reduced to the consistency of thick paint is often used on the trees to prevent the females from laying their eggs on them. These washes should be applied in May or June before the laying of the eggs by the beetles. It is advisable to add glue and Paris green to these washes; the glue to make them more adhesive, and the Paris green may poison the larvae when they begin to bore through the bark.

**The Peach Tree Borer** (*Sanninoidea exitiosa*, Say.)—This is one of the worst enemies of the peach in many sections of the country. It is found in New Mexico but as yet in not very serious numbers. The borer, which is a whitish yel.

low grub, is produced by a moth and when grown is over half an inch in length. The female moth begins to lay her eggs on the bark of the trees usually at the surface of the ground, during June. As the season advances the eggs hatch and

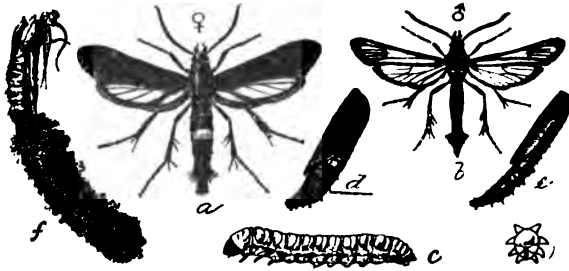


Figure 33. Peach-tree Borer. a, female moth; b, male moth, c, larva; d, female pupa; e, male pupa; f, pupa skin and cocoon. (Marlatt, Cir. 17, B, of Ent., U. S. D. A.)

beneath the bark and just below the surface of the ground. The burrows become filled with a gummy secretion from the tree. The larvae remain in this stage in the tree through the winter and feed again in the spring a short time before they pupate.

*Remedies.*--The *freezing method* and the use of carbon bisulphide have been used in the East but they seem to be unsafe.\* The best and surest way of getting rid of these borers is to dig them out. This method is tedious and somewhat expensive but it is sure. The "digging out" should be thoroughly done on all the trees in all the orchards in the neighborhood every year. The borers should be dug out in June and again in September. The borers will not go down so deep and can be more easily found if the dirt is mounded up a few inches around the base of the trees. Mounding is also credited with keeping out about half to seven tenths of the borers.\* Tobacco stems piled up around the base of the trees have also had the same effect upon the borers as mounding.

Paper bandages are recommended for protecting the trunks of the trees. These protectors keep out a large percent of the borers. Eighteen washes are reported from Cornell University as having been tried against the peach borer.

\*Slingerland, Cornell Bul. No. 176.

Out of this number gas tar was the best all around wash. Slingerland has the following to say on the use of gas tar.

"We used it freely on the same trees for three successive years without the slightest injury to the trees and it kept out nearly all the borers. We had been led to believe that tar was very injurious to young trees, and confidently expected to see our trees die each year after being treated with it. But the trees kept just as healthy and grew as thriftily as any others in the orchard. Let the trees become thoroughly established and get a year's growth, and it is our experience that tar can be used with safety on them. Go slow with it, by first testing it on a few trees in your orchard. We believe it will prove equally effective whether the borers are dug out or not, and from no other application yet devised would we expect to get such results when used independent of the 'digging out' method."

If a wash is used it should be applied early enough in the season and should remain on the tree three or four months.

**The Plum Curculio** (*Conotrachelus nenuphar*, Herbst.)--This beetle is very destructive to the plum. The full grown beetle is about one fourth of an inch in length, brown with grayish black spots. It winters in the adult stage and appears early in the spring, feeding first on the buds and leaves. The female beetle cuts a crescent shaped slit on the plum, raises the flap, and lays its eggs under it. In a

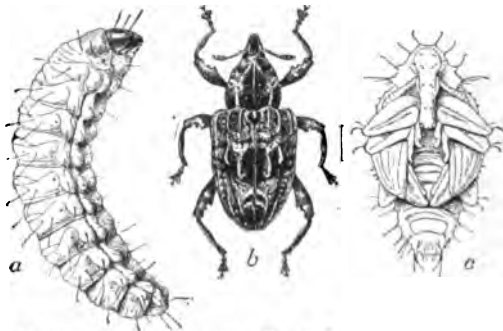


Figure 34. Plum curculio. a, larva; b, adult; c, pupa. (Chittenden, Cir. 73, B of Ent. U. S. D. A.)

few days the egg hatches and the young larva bores into the first fruit and feeds around the pit. This causes the fruit to fall prematurely. As yet this beetle has not been reported in New Mexico; but it is liable to come almost any year and fruit growers should be on the look out for it. Other orchard fruits are also injured by this pest.

**Remedies.**—The spraying of the trees with arsenical mixtures early in the spring before the fruit is set is recom-

mended. The most effective method to combat this insect is to jar the beetles from the trees early in the morning into a sheet stretched under the tree or into a curculio catcher, and kill them. All the fallen stung fruit should be gathered and destroyed as this practice will tend to lessen injury for the next year.

**The Round Headed Apple Tree Borer** (*Saperda candida*, Fabr.)—This is a very injurious beetle to the apple trees and it is beginning to make its appearance in a number of sections in New Mexico. The adult insect measures about  $\frac{3}{4}$  of an inch long, is brown and has two broad white stripes extending the length of the body. The eggs are laid on the bark near the base of the tree during the summer.

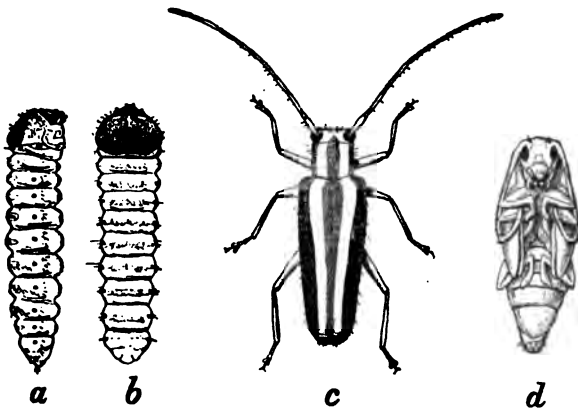


Figure 35. Round-headed apple-tree borer. a, b, larvae; c, female beetle; d, pupa. (Chittenden, Cir. 32, B. of Ent., U. S. D. A.)

three seasons for the larva to reach maturity: the beetles come out during the summer.

**Remedies.**—The larva may be detected first by the discoloration of the bark and later by the castings which have been pushed out of the burrows. The most effective remedy, as for the other tree borers, is the *digging out method*. Of course this means the making of additional wounds on the trees which in some cases may be as bad as the borers. Protecting the trunk of the tree to prevent the laying of the eggs by

The larvae, which are white with round heads and black jaws, hatch within a short time and immediately they begin to bore into the interior of the tree. It takes

the females is recommended. Mosquito netting wrapped around the trunk of the tree is said to be very satisfactory.

The measures used against the peach tree borer ought to give just as good satisfaction with the round headed apple tree borers.

### Spraying Formulas

Sprays may be classed as insecticides, and fungicides, the name indicating the purpose of the spray. Of the insecticides given, the kerosene emulsion, lime-sulphur wash, and whale oil soap are for sucking insects. The Paris green and arsenate of lead are used for the chewing insects.

This bulletin does not treat of any fungus diseases but as the insecticides are often times used in the same operation the formula of the Bordeaux mixture has been included. It is quite common to use Paris green or arsenate of lead and Bordeaux mixture together.

### Insecticides

#### *Kerosene Emulsion*

|               |           |
|---------------|-----------|
| Soap.....     | ½ pound   |
| Kerosene..... | 2 gallons |
| Water.....    | 1 gallon  |

Cut the soap in small pieces so it will dissolve quickly in one gallon of boiling water. Remove the solution from the fire and add the two gallons of kerosene and churn or agitate with a small force pump, by pumping it back in the bucket, until it becomes creamy and the oil does not separate. This operation may take from five to ten minutes. If used during the dormant period of the tree dilute the stock solution from one to five times. For plant aphids in summer on foliage dilute from 20 to 50 gallons. This solution is being replaced by the lime sulphur wash as a winter spray.

*The Oil-Water treatment*, which is a mixture of kerosene or crude petroleum with water in the act of spraying, is sometimes used in place of the kerosene emulsion. Pumps are now made for the purpose of making the mixture at 5 to 25

percent oil. These pumps do not always work satisfactorily.

*Pure kerosene* is sometimes used as a winter spray on trees for San José scale. This method of combating the San José scale has been tried by a few fruit growers in the Mesilla Valley with satisfactory results. It is claimed that if a spray is used shortly before the buds begin to swell in the spring that the danger of injuring the trees will be lessened.

*Whale-Oil soap* is used for the scale insects when trees are dormant, at the rate of one to two pounds dissolved in one gallon of warm water. The spray is most effective when applied quite hot. When applied for plant aphids or lice during the summer, dissolve one pound in eight to ten gallons of hot water.

*Tobacco Decoction* is a mixture frequently used for plant lice. Boil for about 30 to 40 minutes one pound of tobacco dust or stems in water and use without more diluting.

*Hot Water* heated from 130 to 140 degrees F. is sometimes used and will kill most any insects. It is harmless to plants unless they are kept submerged for a long while.

*Pyrethrum* which is a vegetable powder may be used either wet or dry. If wet, use one ounce in three gallons of water. Where the dry powder is applied, if pure, use it quite lightly or it may be diluted with flour and put on more freely.

#### *Lime Sulphur Wash*

|                               |            |
|-------------------------------|------------|
| Good unslaked stone lime..... | 20 pounds  |
| Flowers of Sulphur.....       | 15 pounds  |
| Water... ..                   | 50 gallons |

In preparing this spray mix the sulphur into a thin paste with just enough water to break up all the lumps. Take a large kettle with 15 gallons of water, place it on a fire and heat it to the boiling point. Add the sulphur paste to the boiling water and mix it thoroughly. Then add the 20 pounds of stone lime and while the lime is slaking stir often and vigorously enough to keep the lime and sulphur well mixed.

Keep the mixture boiling vigorously for at least an hour or until a dirty orange color appears. If salt is to be used with lime and sulphur, 10 pounds can be added at any time as it dissolves quite readily.

When the mixture has boiled long enough it is ready to be strained into the spraying barrel and diluted to the 50 gallons. It is better to dilute the wash with warm water. The diluted mixture should still retain its orange color. If a light yellow color appears the wash has not been boiled long enough. The mixture should be taken immediately to the orchard and sprayed upon the trees while still warm.

The time to spray for the San José scale with lime-sulphur wash is while the trees are dormant, that is, any time during the winter and spring. In badly infested orchards more satisfactory results will be secured by spraying twice, once in the fall and once in the spring. In slightly affected orchards one spraying, carefully and thoroughly done, will give very satisfactory results.

*Paris Green* has been the most common poison but it is not used so much at present.

|                  |                     |
|------------------|---------------------|
| Paris Green..... | 1 pound             |
| Fresh lime. .... | 2 to 4 pounds       |
| Water.....       | 100 to 200 gallons. |

A paste should first be made of the Paris green in a small quantity of water. Slack the lime, mix it with the Paris green and put the solution in the barrel or tank and apply. The Paris green settles quite readily and to prevent this while spraying, the solution should be kept agitated. On peaches, apricots, nectarines, beans and other sensitive foliage use the weaker strength, while apples, cherries, potatoes, beets, and cabbage may be safely sprayed with the more concentrated solution. Paris green, which is often used with the Bordeaux may be put into the solution, thus making one spray do for insects and fungous diseases.

*Arsenate of Lead* is a compound that is superior to other arsenicals and is taking their place to some extent. It can be used very strong without injuring the more sensitive



plants. It remains in suspension longer and has better adhesive qualities than the other arsenicals used.

The arsenate of lead can be bought already prepared. Disparene, Swift's Arsenate of Lead, and Rex Arsenate of Lead are some of the brands. Three to four pounds of the prepared compounds may be used to every 50 gallons of water. Weigh out the amount needed and put it in a vessel containing a little water. Stir the mixture until there are no lumps of arsenate. Put the milky solution in the barrel or tank and begin to spray. This Station has been buying the prepared arsenate of lead from the Barteldes Seed Co., of Denver, Colo., at 13 to 15 cents per pound.

If the commercial preparation cannot be secured the poison can be made by taking 4 ounces of arsenate of soda, 11 ounces of acetate of lead (white sugar of lead) and 16 gallons of water, each ingredient being dissolved separately in two quarts of warm water, then mixed together and diluted to 16 gallons.

Arsenate of soda and arsenite of lime are not used now as much as formerly. For a full discussion of these two sprays see New Mexico bulletin No 41.

*Bordeaux mixture.* This is the remedy for rots, mildews, and all fungous diseases and it is prepared as follows:

|                                   |             |
|-----------------------------------|-------------|
| Copper sulphate (blue stone)..... | 6 lbs.      |
| Fresh lime.....                   | 4 to 6 lbs. |
| Water.....                        | 50 gallons  |

Put the copper sulphate in a coarse sack and suspend it in a wooden or an earthen vessel with some water until it is all dissolved, and then dilute to 25 gallons. Slake the lime and dilute it to 25 gallons, then pour the two mixtures together, at the same time stirring with a paddle. An important point is to use enough lime, as it prevents the burning of the foliage. To determine if enough lime has been used, in preparing the mixture, add a few drops of a solution of ferro-cyanide of potassium. If the ferro-cyanide of potassium does not change, no more lime is needed, but if it changes to a dark reddish color more lime must be added and the test repeated. To this mixture add either the Paris green or arsenate of lead as the case may be and proceed to spray.

Bulletin No. 145 of the Kansas Experiment Station gives the following probable cost of spray materials:—

**PROBABLE COST OF MATERIALS**

|                         | Cents     |
|-------------------------|-----------|
| Arsenate of lead.....   | 13 to 15  |
| Paris green. ....       | 18 to 24  |
| Acetate of lead.....    | 12½ to 14 |
| Arsenate of soda.....   | 10 to 12  |
| Copper sulphate.....    | 7½ to 8½  |
| Flowers of sulphur..... | 3         |
| Lime . . . . .          |           |

**Cost of Bordeaux**

|                               | Cents |
|-------------------------------|-------|
| 5 pounds copper sulphate..... | 40    |
| 5 pounds lime.....            | 3     |
| 50 gallons water. ....        | 0     |
| Total. ....                   | 43    |

**Bordeaux with Paris Green**

|                               | Cents |
|-------------------------------|-------|
| 5 pounds copper sulphate..... | 40    |
| 5 pounds lime... ..           | 3     |
| 50 gallons water.....         | 0     |
| 6 ounces Paris green.....     | 9     |
| Total. ....                   | 52    |

**Bordeaux with Arsenate of Lead**

|                                | Cents |
|--------------------------------|-------|
| 5 pounds copper sulphate.....  | 40    |
| 5 pounds lime.....             | 3     |
| 50 gallons water.....          | 0     |
| 3 pounds arsenate of lead..... | 40    |
| Total. ....                    | 83    |

## APPENDIX

**Spring Grain Aphis, Otherwise Known as "Green Bug"\***

By F. M. WEBSTER,

In Charge of Cereal and Forage Plant Insect Investigations, U. S. D. A.

The original home of this insect is doubtless Southern Europe, although it sometimes does considerable injury to oats in Hungary, and Dr. Hovarth, of the Hungarian National Museum, has reported it from Siberia. Just how the transportation from its native home in Europe to America was accomplished, it is now impossible to say, as it is also impossible to state where in the Western continent this introduction took place. It will suffice for economic purposes to say that it is one of the most destructive of all species of aphides known in America, and its outbreaks in the Southern states are, of all other insect attacks, the most disastrous.

Very fortunately these serious outbreaks have occurred at long intervals. The first serious outbreak of this pest occurred in 1890, and extended from northern Texas to Missouri, southern Illinois and southern Indiana; probably about the latitude of St. Louis might be stated as its northernmost limit of destructive abundance. There are very many peculiarities of this insect that tend to cause its outbreaks to be very erratic, distributed over wide areas of country and causing immense destruction. Its life history in the extreme south is yet enveloped in obscurity, so that the facts here given must not be held to apply too strictly to the country covered by South Carolina, southern Georgia, Alabama, Mississippi, Louisiana, Texas and New Mexico; neither should it be applied with any greater exactness to the Pacific Coast regions. We know that it occurs on the Atlantic Coast from South Carolina to Pennsylvania, and from southern Pennsylvania diagonally northwest to extreme northern Minnesota, and from the Gulf of Mexico and Rio Grande river to northern North Dakota.

This covers the known area of its distribution east of the Rocky Mountains. Recently, it has been found on the Pacific Coast, but its distribution there is not yet known. As would be inferred from its wide distribution and its occurrence at elevations from very near sea level to upwards of five thousand feet, it can withstand almost any variety of climate. It will breed freely when the temperature during a large portion of the 24 hours is below freezing point and also under a temperature of 100° Fah. Viviparous females that have remained in the field at a temperature of a little above zero, when brought into a warm room, have begun to breed freely as soon as they became thoroughly revived by the warm atmosphere.

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\*This insect has been found this summer in the Pecos and Rio Grande Valleys by C. N. Ainslie, Special Agent of the Bureau of Entomology, U. S. D. A.

While we can give the life history of the insect fairly well in certain localities, it would be too much to apply this to the whole area of its distribution with the great variety of climatic influences and effects of elevation.

Generally speaking the insect during the warm months is viviparous; that is to say the females give birth to their young and no males are present. In the fall there are to be found both males and egg-laying females. In the north the insect, at least to a certain extent, passes the winter in the egg stage; but during mild winters there still remains in the fields viviparous mothers who simply cease reproduction as the temperature lowers, only beginning again when the weather gets warm. Of course this characteristic is intensified as we go southward and we should not be at all surprised to find both males and egg-laying females in spring; and, indeed, it would not be surprising if we find that the dry season is more or less bridged over in this stage. This will show the obscurity in which the habits of the insect in New Mexico are enveloped and which it will be necessary to work out before we can give very definite statements as to the exact habits of the insect in its southern home.

The pest increases very rapidly, young becoming fully developed and reproducing in six to eight days. A single female may become the progenitor of 50 to 60 young, and long before she has ceased to reproduce she will have become a great great grandmother. So far as we are able to learn the number of eggs produced by an individual, egg-laying female is very limited, probably less than half a dozen. It is therefore in every way probable that it is to the viviparous females living over in the fields that the disastrous outbreaks in the Southwest are due. Thus these outbreaks become more a matter of weather conditions than anything else.

The insect is normally controlled by its natural enemies. A little wasp like insect known as *Lysiphlebus tritici* is the principal enemy to keep it within bounds and prevent its occurring in destructive abundance. This valuable little parasite passes its entire development within the abdomen of the grain aphid, and the time required is about ten days, but varies much with the temperature. They are entirely dormant with the temperature below about 56° and thus it is that mild winters followed by a cold backward spring are extremely favorable for outbreaks of this so-called green bug, because the latter will continue to breed with extreme rapidity, while its parasites are kept dormant, and it is only when the weather gets sufficiently warm and remains so for ten days or two weeks that this natural enemy gets the upper hand and finally overcomes the grain aphid, which, unfortunately, does not occur until after the pest has bred in immense swarms in the

grain fields and killed the crops, leaving the fields as brown as though they had been scorched by fire.

At the present time there is no way of foretelling the outbreaks of this pest. It now occurs in limited numbers over the entire area of distribution as previously given; but with normal winters and springs, in all probability, no damage will occur, but a repetition of the winter and spring of 1907 is almost certain to bring on another disastrous outbreak.

While preferring the grain crops, more especially wheat and oats, it may become in the north quite destructive to blue grass and orchard grass. It can doubtless live in the south on a number of other grasses but the extent to which this is true is yet to be definitely determined. As will be observed by the foregoing, preventive measures are quite difficult to put into operation, even if we were familiar with them. The first outbreak of the pest was in 1890, and it was eleven years before another disastrous outbreak occurred, and six years more before a second occurred, so that the application of preventive measures will be somewhat difficult to carry out unless made perpetual and against an enemy that is less likely to occur than not.

As to remedies, it seems to be the case in the South that the insect first makes its appearance in spots in fall sown grain, the earlier the grain is sown the more likely it is to be infested. We have found that, taken in time, these spots may be treated by plowing under, spreading straw upon them and burning, or by spraying with kerosene emulsion. If the spots are very small this method is more practical than may at first appear. After the insects have once become thoroughly diffused and abundant in the field there does not appear to be any way of preventing their destructive work. We have tried rolling and brushing fields with no beneficial results. Of course the spraying of an entire field is out of the question.

The Bureau of Entomology has now a large force of men in the field investigating this pest over its entire area of distribution in the United States. We are making every effort to accumulate facts with the hope of being able to advise grain growers as to the best methods of evading future attacks. It would seem that if disastrous outbreaks could be prevented in the states bordering the Gulf and the Rio Grande river, some, at least, of the damage farther north might be prevented; as it is certainly a fact that when the pest develops in such immense swarms as it did in Texas in the spring of 1907, it gradually drifts northward as the season advances, and the destruction throughout the states farther north is in all probability greatly increased through this feature of its development.

Whatever is done to prevent the destruction caused by this insect will have to be something that can be carried out in ordinary farm methods, or else applied to extremely small areas where the pest first makes its appearance in the fall.

### **New Mexico Law on Orchard Inspection**

Section 1. Within twenty days after the passage of this act it shall be incumbent upon the county commissioners of each county of New Mexico, on petition of ten tax-paying citizens of said county, to select three competent persons, fruit growers, or owners of orchards, residents of such county, who shall be known as the County Board of Horticultural Commissioners. The board of county commissioners shall fill any vacancy that may occur in said board by death, resignation, or otherwise, and appoint one horticultural commissioner each year, or thereabouts, one month, or thereabouts, previous to the expiration of the term of office of any member of the said county board of horticultural commissioners. Said county board of horticultural commissioners shall serve for a term of three years from date of appointment, except the commissioners first appointed, one of whom shall serve for one year, one of whom for two years, and one of whom for three years from date of appointment. The commissioners first appointed shall themselves decide by lot or otherwise, who shall serve for one year, who shall serve for two years, and who shall serve for three years, and shall notify the board of county commissioners of the result of their choice.

Sec. 2. It shall be the duty of the county board of horticultural commissioners in each county, whenever it shall deem it necessary, to cause an inspection to be made of any orchard, or nursery, or trees, or any fruit packing house, store-room, sales-room, or any other place in their jurisdiction, and if found infested with scale bug, codling moth or other insect pest injurious to fruit, trees, and vines, they shall notify the owner or owners, or person or persons in charge or possession of said trees or place, aforesaid, that the same are infested with said insects, or any of them, or their eggs or larvae, and they shall require such person or persons to disinfect or destroy the same within a certain time, to be specified: Provided, that no spraying of trees while in bloom shall be required to be done. If within such time such disinfection or destruction has not been accomplished, the said person or persons shall be required to make application of such treatment for the purpose of destroying them as said commissioners may prescribe. Said notices may be served upon the person or persons owning or having charge or possession of such infested trees or places, or articles as aforesaid, by any commissioner, or by any person deputed by the said commissioners for that purpose, or they may be served in the same manner as a summons in a civil action. If the owner or owners, or persons in charge or possession of any orchard, or nursery, or trees or places, or articles, infested with said insects, or any of them, or their larvae or eggs, after having been notified as above to destroy the same, or make application of treatment as

directed, shall fail, neglect, or refuse to do so, he or they shall be deemed guilty of maintaining a public nuisance, and any such orchards, nurseries, trees, or places, or articles thus infested shall be adjudged and the same is hereby declared a public nuisance, and may be proceeded against as such. If found guilty, the court shall direct the aforesaid county board of horticultural commissioners to abate the nuisance. The expenses thus incurred shall be a lien upon the real property of the defendant.

Sec. 3. The said county board of horticultural commissioners shall have power to divide the county into districts and to appoint a local inspector for each of said districts. The board of county commissioners of each county shall issue commissions as quarantine guardians to the members of said county board of horticultural commissioners, and to the local inspectors thereof. These quarantine guardians, local inspectors, or members of said county boards of horticultural commissioners, shall have the authority to enter into any orchard, nursery, or place or places where trees or plants are kept and offered for sale, or otherwise, or any house, store-room, sales-room, depot, or any other such place in their jurisdiction, to inspect the same, or any part thereof.

Sec. 4. It shall be the duty of said county board of horticultural commissioners to keep a record of their official doings, and to make a report to the board of county commissioners on or before the first day of October of each year, of the condition of the fruit interests in their several districts, what is being done to eradicate insect pests, also as to the disinfecting and as to quarantine against insects, pests and diseases, and as to carrying out all laws relative to the greatest good of the fruit interest. Said board of county commissioners shall incorporate so much of said report as may be of general interest in their annual report which they shall make to the governor of said territory on or before the first day of December of each year.

Sec. 5. Each member of the county board of horticultural commissioners, and each local inspector, shall be paid for each day actually engaged in the performance of his duties under this act, payable out of the county treasury of his county, such compensation as shall be determined by resolution of the board of county commissioners of the county, before entering into the discharge of his or their duties.

Sec. 6. Said county board of horticultural commissioners shall have power to remove any local inspector who shall fail to perform the duties of his office. If any member of the county board of horticultural commissioners shall fail to perform the duties of his office, as required by this act, he may be removed from office by the board of county commissioners, and the vacancy thus formed may be filled by appointment by said board of county commissioners. In addition to the

annual report required, by section 5 of this act, the county board of horticultural commissioners shall make a monthly report of their doings to the board of county commissioners and the board of county commissioners may withhold warrant for their salary or compensation of said members and inspectors thereof until such time as said report is made.

Sec. 7. The board of horticultural commissioners may receive, manage, use and hold donations, and bequests for promoting the objects of its formation. It shall meet semi-annually, and as much oftener and at such places as it may deem expedient, to consult and adopt such measures as may best promote the horticultural industry of the county. It may, but without expense to the county, select and appoint competent and qualified persons to lecture in the county, for the purpose of illustrating practical horticultural topics, and imparting instruction in the methods of treating diseases of fruits and fruit trees, cleansing orchards and exterminating insect pests. The county board of horticultural commissioners, shall at their first meeting select from among themselves a chairman, a secretary and a treasurer who shall furnish bond to the county commissioners in the sum of five hundred dollars (\$500.00) for the faithful discharge of his duties.

Sec. 8. The chairman shall preside at all meetings of the board, shall countersign all checks for moneys paid out, and shall sign all contracts to which the county board of horticultural commissioners is a party: Provided, the same shall have been approved by the board. He shall have power to call a meeting of the board at any time he deems it necessary, whenever requested by a majority of the board, or when requested in writing by six of the resident fruit growers.

Sec. 9. The secretary shall attend all meetings of the board, and preserve records of all its proceedings and all its correspondence, collect and preserve such books, pamphlets, periodicals and other documents as may be of interest to the horticulturist, and to correspond with agricultural and horticultural societies and colleges and what other persons and bodies as he may be directed by the board. He shall also prepare such reports as are required by the board, and perform such other duties as will pertain to the office.

Sec. 10. The duties of the treasurer shall be to receive and safely keep all moneys of the board. He shall pay out the same only for bills approved by the board, and shall render a detailed account to the board before the first of October of each year, or as often as may be required by the board, showing the amount of money received by the board and paid out by him. At the expiration of his term of office he shall turn over to his successor in office all moneys, books, and papers of the board. He shall give bond in sum as provided for.



### Acknowledgments

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Comstock—Manual For The Study of Insects.

Smith's—Economic Entomology.

Hunter's—Elementary Studies in Insect Life.

Chittenden—Insects Injurious to Vegetables.

Sanders—Insects Injurious to Staple Crops.

Saunders—Insects Injurious to Fruits.

New Mexico Bulletin No. 35.

Colorado Bulletins Nos. 112 and 114.

Kansas Bulletin No. 145.

Utah Bulletin No. 65.

Michigan Bulletin No. 233,

Texas Bulletin No. 89.

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New Mexico College of Agriculture and Mechanic Arts

AGRICULTURAL EXPERIMENT STATION

AGRICULTURAL COLLEGE, N. M.

EXPERIMENTS ON THE  
DIGESTIBILITY OF PRICKLY PEAR  
BY CATTLE.

BY

R. F. HARE

SANTA FE, N. M.  
NEW MEXICAN PRINTING COMPANY  
1908.

# **New Mexico Agricultural Experiment Station.**

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# EXPERIMENTS ON THE DIGESTIBILITY OF PRICKLY PEAR BY CATTLE.

## INTRODUCTION.

Many chemical analyses have been made of a number of different members of the cactus family to determine their value as a feeding stuff for animals.\* With this data we are enabled to judge with a fair degree of accuracy the amount of the various nutrients contained by many different species of this group of plants, as well as by different parts of the same plant. However, as no record of digestion experiments with any of the cacti has been found, it was impossible to say what proportion of the different nutrients were available to the animals. The increased use of the prickly pear (the flat-jointed members of the genus *Opuntia*) as feed for all classes of ruminants, especially for range and dairy cattle, makes it important for the proper preparation of a ration that the feeder know how much digestible nutrients to expect from feeding a given quantity of the plant either alone or mixed with other feeding stuffs. The following experiments have therefore been conducted to determine the digestibility of prickly pear and thus guide the feeder in the preparation of rations from this plant.

The investigations have been conducted in cooperation with the Office of Farm Management Investigations, Bureau of Plant Industry, United States Department of Agriculture. The author acknowledges the assistance of Dr. David Griffiths, of that Office who has spared neither time nor pains in an effort to make the experiments successful. Acknowledgement is made of the careful and painstaking analytical chemical work of Messrs. S. R. Mitchell and R. B. Deemer.

## METHOD OF CONDUCTING DIGESTION EXPERIMENTS.

The principle of conducting a digestion experiment is very simple. First, the animal is fed the feeding stuff the digestibility of which is to be determined until all other feeds have been

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\* See Bulletin 60 of the New Mexico Experiment Station.

removed from the alimentary canal, when the animal is said to be in a condition of equilibrium with this feed. The animal is then placed in a stall specially designed for feeding and for collecting refuse and excreta without waste. It is then fed a weighed amount of the feeding stuff, the composition of which is determined by analysis. All the refuse is collected, weighed, analyzed, and the amount of the several nutrients which it is found to contain is subtracted from the amount of the corresponding nutrients fed. As nearly as possible that portion of the feces which corresponds to the weighed feed eaten is carefully collected, weighed, and analyzed. The amount of the different nutrients found in the feces subtracted from the amount eaten gives the amount of each nutrient digested. This result, multiplied by 100 and divided by the amount eaten, gives the percentage of digestible nutrients, which is called the "coefficient of digestibility."

#### DEFINITION OF SOME TECHNICAL TERMS AND DISCUSSION OF THE FUNCTIONS OF FOOD.

Most of the readers of these pages will doubtless be familiar with the technical terms that are used throughout this bulletin and understand how the value of a feeding stuff is determined from its analyses and from the digestion coefficient of the several nutrients, but it may not be amiss briefly to define and discuss them here for the benefit of the few who may not be thoroughly familiar with them. For this reason there are given below definitions of some of the terms used, with the names of the constituents that are usually determined in fixing the value of a feeding stuff, and a brief discussion of the functions of each in the animal body.

It should be remembered that in the feeding of animals the amount of nourishment obtained from any feed by an animal does not altogether depend upon the weight of the feed taken into the body. Green matter, for instance, with 60 to 95 per cent of water will not, of course, furnish as much substance as will cured fodders and grains. The scientific feeder must not only prepare the rations for his animals on the basis of the amount of dry matter present, but it is also necessary that he should know how much nourishment a given amount of this dry matter can furnish them. The dry matter of the different feeds has been found to vary greatly in the amount of nutrients which it contains as well as in its digestibility. A feed which has been adulterated with



cotton-seed hulls, chaff, sawdust, or other fibrous and insoluble or difficultly soluble matter would not, for instance, be as digestible, and consequently could not furnish as much nourishment pound for pound, as some feed in which the nutrients were in a form more readily available to the animal. It is, therefore, not only necessary that the amount of dry matter in a feed be known, but it is equally important to know the character and composition of this dry matter.

The animal body is made up of water, mineral matter (or ash), nitrogenous matter (or proteids), and fat. The function of the feed which animals eat is to maintain the supply of these materials so that they may grow, perform work, and maintain a healthy condition.

It is a well-established fact that all feeds have certain groups of substances that perform their peculiar functions in building the different parts of the animal body, and the object of a chemical analysis of any feeding stuff is to separate and determine these groups. They are usually separated into the following: Water, ash, ether extract, crude fiber, protein, nitrogen-free extract, and organic matter. The last named represents a sum of the preceding four, and together with the mineral matter they are all called nutrients. The value and function of each of these classes of nutrients are briefly discussed below.

#### COMPOSITION OF FEEDING STUFFS.

*Water.*—All foods, however dry they may appear, contain some moisture. Air-dry corn meal or wheat flour, for example, which may appear perfectly dry will, on the complete removal of their water, be found to have contained from 5 to 15 per cent. Some root crops and vegetables may contain as much as 95 per cent, or even more, of water. The water naturally present in feeding stuffs may cause them to be more succulent and thus doubtless aids their digestion, but an increase in the water means a necessary decrease in the actual amount of food material present, hence its presence instead of adding to, merely detracts that much from the value of any feed; especially is this true of the concentrated feeds.

*Mineral matter, or ash,* is that portion which is left after complete combustion of the plant. While a certain amount of ash is necessary for supplying mineral matter to animals and in building bones in the young, there is usually an abundance pres-

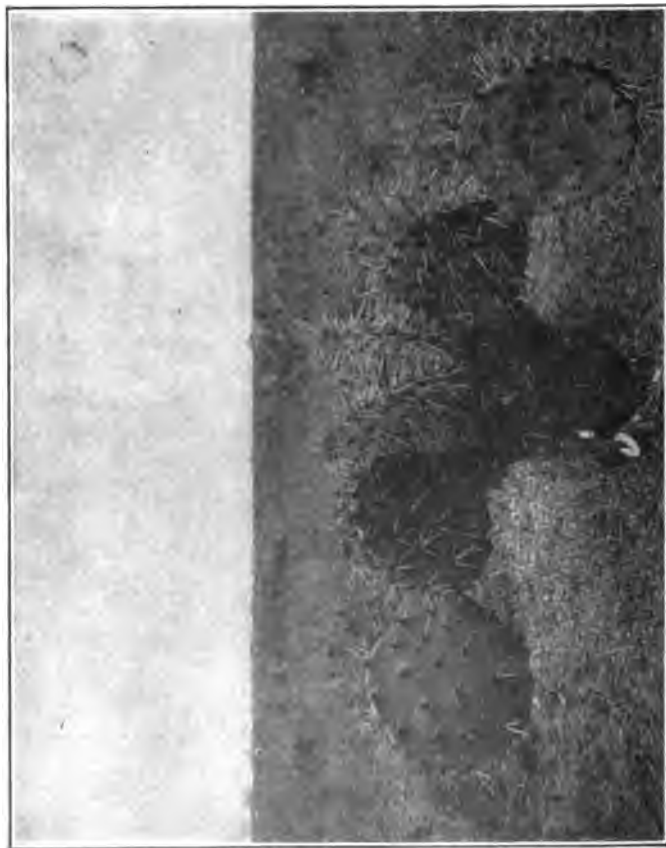


Fig. 1.—*Opuntia lindheimeri*. Two-year-old second growth of species fed in the first experiment.

ent in all foods; and for this reason no commercial value is placed on the amount of ash contained in the food, as is the case with proteids, carbohydrates, and fats.

*Protein* is a name given to a group of very complex compounds which are characterized by the fact that they all contain the element nitrogen combined with carbon, hydrogen, oxygen, and small amounts of sulphur and sometimes phosphorus. Albumen of eggs, casein of milk, and fibrin of blood are examples of protein compounds. Protein is that material in the food which serves as a flesh former, and is the only substance of the food that can be used to build muscular tissue, skin, hair, horns, blood, and connective tissue. It may also, when in abundance, serve the function of the carbohydrates and fats of the food. Alfalfa, cotton-seed meal, all the clovers, and wheat bran are examples of feeds rich in this nutrient; while prickly pear, straw, roots, and tubers contain it in very small amounts. Because of its importance in the dietary, and the fact that it is not present in sufficient amounts in all feeds to supply the needs of animals, it is usually the most expensive of all the nutrients. In one State having a feeding-stuff law a value of 2.3 cents a pound was placed upon the protein which the food contained, while the carbohydrates (nitrogen-free extract and crude fiber) and fats were priced at 0.94 and 1.14 cents, respectively. This is about an average of the prices usually placed on these nutrients.

In the Southwest, where alfalfa, wheat bran, and cotton-seed meal are three of the principal feeds, animals usually get an excess of protein over the amount which they require, and this excess is undoubtedly used to serve the function of fats and carbohydrates—that is, to furnish heat and other forms of energy and to produce fat. Because of the fact that the feeds mentioned above are the most abundant ones for this section, if a commercial value were placed on their various nutrients the proteids should be cheaper than the carbohydrates and fats, and such is often the case. Wheat bran, cotton-seed meal, and alfalfa are usually found to be cheaper than corn and other starchy grains and hays.

While the various groups of proteid compounds are alike in that the element nitrogen is common to them all, they vary greatly in the proportional amount of nitrogen which they contain as well as in their value for building flesh and muscle. Strange to

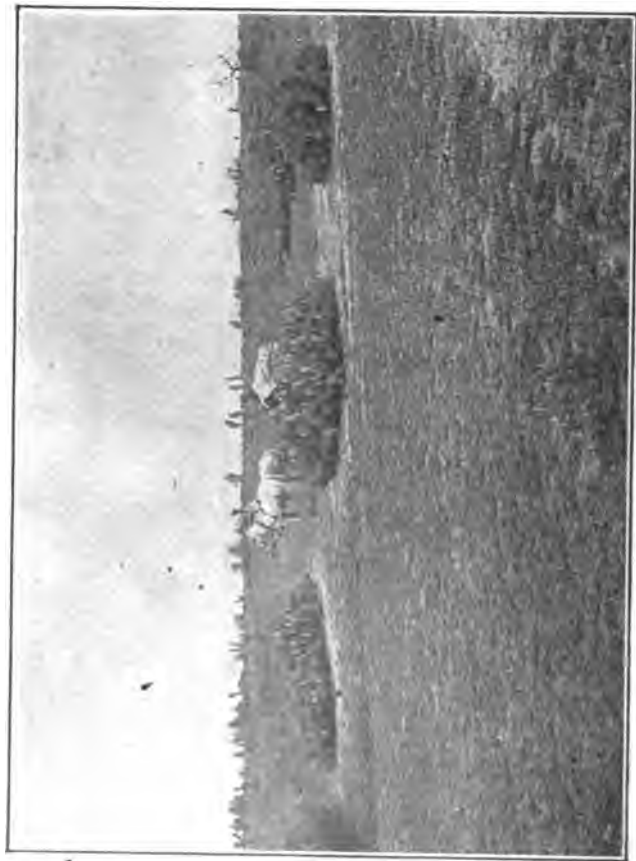


Fig. 2.—*Opuntia engelmannii cycloides*, old plants of species fed in the third experiment.

say, it is not those groups which contain the most nitrogen that are the most valuable for this purpose. Those of most value as flesh formers are the so-called true proteids, or albumin-like substances that contain about 16 per cent of nitrogen. These are most abundant in grains and mature fodders. There are simpler group of protein compounds which the chemist calls amids and amins, or better, nonproteid nitrogen compounds. They may contain 20 per cent or more of nitrogen. They are the first products formed by the plant in the synthesis of nitrogen compounds from the ammonia of the soil. They may be found in the young and tender parts of the plant or in the fruits, and in roots and tubers. It has been shown that these nonproteids can prevent the waste of tissue when used as a substitute for albumin in food, but they are unable to replace the latter in building flesh.

*Fat* is the portion that is dissolved when the dried powdered food is treated with ether. This treatment theoretically dissolves fats only, but practically small amounts of gums, resins, chlorophyll, and other substances go into solution with this reagent, and the material thus dissolved is often and perhaps better termed ether extract. The fats, like the carbohydrates, are used as heat and energy producers, and they are about two and one-fourth times as valuable as the latter for that purpose. One pound of fat yields 4,220 Calories.\*

*Crude fiber* is the portion of the food that constitutes the framework of the plant. In the analysis it is the part remaining after the finely ground food has been thoroughly treated successively with ether and hot dilute acid and alkali.

*Nitrogen-free extract* is represented by the sugars and starches, and includes all of those compounds of carbon, hydrogen, and oxygen that are dissolved by boiling the fat-free material consecutively for thirty minutes each in dilute acid and alkali of definite strengths. All of this group of bodies, together with that part of the crude fiber, which is digested by the animal, are collectively called carbohydrates. They serve the same function as the fats in the animal system, but are not so concentrated a food. One pound of carbohydrates yields about 1,860 Calories, hence we

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\* One Calorie is the amount of heat required to raise the temperature of 1 kilogram of water 1 degree centigrade, or 1 pound of water 4 degrees Fahrenheit.

say that fats which yield 4,220 Calories per pound have two and one-fourth times the value of carbohydrates as heat producers.

#### FUNCTIONS OF THE NUTRIENTS.

The two main functions of food are to produce tissue and to furnish energy. Proteids alone are used for the former purpose, while fats, carbohydrates, and excess of proteids can all be used for the latter. The amount of food used for building tissue is comparatively small, hence the ratio of proteid to non-proteid nutrients may be quite wide, especially for grown animals that are doing hard work.

Since the important functions of any food are performed by the proteids and nitrogen-free nutrients (fats and carbohydrates) which they contain, the amount of these present and in a form available to the animal is a measure of the value of that food.

#### METHOD OF DETERMINING THE DIGESTIBLE NUTRIENTS OF PRICKLY PEAR FROM THE COMPOSITION AND DIGESTION COEFFICIENTS.

An average of several analyses of a certain variety of prickly pear (*Opuntia lindheimeri*) shows it to have the following composition: Water, 83.41 per cent; ash, 3.48 per cent; protein, 0.75 per cent; ether extract, 0.31 per cent; crude fiber, 2.64 per cent; nitrogen-free extract, 9.41 per cent; total organic matter, 13.11 per cent.

By feeding this plant to steers we find the following coefficients of digestion of the nutrients present for this class of animals: Protein, 58.25 per cent; fat (ether extract), 67.90 per cent; crude fiber, 41.32 per cent; nitrogen-free extract, 82.59 per cent. With these figures we calculate the following digestible nutrients from the above analyses by multiplying each nutrient by its coefficient: Proteids, 0.45; fat, 0.21; carbohydrates, 7.77. The nutritive ratio, or the ratio between digestible proteids and Nitrogen-free material, i. e.,  $\text{fat} \times 2.25 \div \text{total carbohydrates}$ , in this sample of the plant, is 1 to 18.3.

#### PREPARATION OF STANDARD RATIONS.

As before stated, the value of a feed does not necessarily depend upon the amount of proteids, carbohydrates, and fats which it contains, but rather upon the amount of these contained in the feed that is available to animals. If digestion experiments show that a comparatively large amount of the nutrients pass into the feces, then in order that the animal may secure sufficient nutrients to

supply the purpose sought there must be a corresponding increase of the ration. For the guidance of the feeder in the proper preparation of his ration, the digestion coefficient has been determined for practically all ordinary feeds and for the several kinds of farm animals. Experience has proven that the best results are obtained in feeding when the digestible nutrients are fed to the animal in certain definite amounts. Tables of feeding standards have been compiled by German and American scientists in which are given the daily amounts of each nutrient required by our common farm animals of a given weight and for a specific purpose. In the feeding of milch cows, for example, the standard fixed by the German scientist Wolff is the one probably most used in this country at present. It is based on observations of the feeding practices of the best German feeders, together with feeding experiments by trained specialists. There is a prevalent opinion in the United States that the Wolff standard for milch cows is somewhat higher in proteids than is necessary for the best American ration. Several attempts have been made by scientists in the United States to determine what the proper standard is for this country. Below is given a table taken from the Connecticut (Storrs) Experiment Station report for 1894, in which is given the German standard, together with four rations which have been proposed by different authorities for the United States.

TABLE 1.—*German (Wolff's) standard ration together with averages of some American rations and a tentatively suggested ration per, 1,000 pounds live weight.*

| Rations.                                                                       | Organic matter. | Digestible nutrients. |            |               |             | Nutritive ratio. |
|--------------------------------------------------------------------------------|-----------------|-----------------------|------------|---------------|-------------|------------------|
|                                                                                |                 | Protein.              | Fat.       | Carbohydrates | Fuel value. |                  |
|                                                                                | Pounds.         | Pounds.               | Pounds.    | Pounds.       | Calories.   |                  |
| Wolff's (German) standard..                                                    | 24.0            | 2.50                  | 0.40       | 12.50         | 29,600      | 1:5.4            |
| Average of 128 American rations, compiled by the Wisconsin Experiment Station. | 24.5            | 2.15                  | 0.74       | 13.27         | 31,250      | 1:6.9            |
| Average of 16 rations as fed in Connecticut in 1892-93...                      | 26.4            | 2.48                  | 0.94       | 14.09         | 34,800      | 1:6.5            |
| Average of 25 rations as fed in Connecticut in 1892-94...                      | 26.8            | 2.51                  | 0.90       | 13.92         | 34,350      | 1:6.3            |
| Tentatively suggested ration *.....                                            | 25.0            | 2.50                  | 0.5 to 0.8 | 13 to 12      | 31,000      | 1:5.6            |

\* In this suggested ration the fuel value could be supplied by about 0.5 pound of digestible fat and 13 pounds of digestible carbohydrates; by 0.6 pound of digestible fat and 12.5 pounds of digestible carbohydrates; or by 0.8 pound of digestible fat and 12 pounds of digestible carbohydrates.

It will be seen from the table, that about the only material change recommended by American scientists consists in an increase of the fats and carbohydrates. It would appear that this much difference might almost result from individuality, and the feeder would be safe in using any of these rations that common sense, good judgment, and his experience with the individual animals would indicate to him to be best. In New Mexico, where proteid feeds are cheap, the nutritive ratio of the Wolff standard would probably not be too narrow. In fact, narrower rations than those proposed by him are used here constantly with splendid results.

By the use of the above table a balanced ration can be prepared from prickly pear when its digestible nutrients are known, by so mixing it with other feeds as to obtain the nutrients in the right proportion. Suppose, for example, we desire to prepare a ration composed in part of prickly pear for a 1,000-pound milch cow yielding 22 pounds of milk per day. Using the Wolff standard of 2.5 pounds protein, 0.5 pound fats, and 13 pounds carbohydrates as our basis, and feeding 100 pounds of prickly pear per day, the cow would get the following nutrients, as calculated above from the species *Opuntia lindheimeri*: Proteids, 0.45 pound; fats, 0.21 pound; carbohydrates, 7.77 pounds. This leaves a balance of 2.05 pounds protein, 0.29 pound fat, and 5.23 pounds carbohydrates to be supplied by some other feed. Since the ratio of proteids to non-proteids (nutritive ratio) in this variety of pear is 1 to 21.7, and a ratio of 1 to 5.7 is the Wolff standard for such a cow, it is evident that some feed rich in protein should be mixed with the prickly pear to narrow it down to this ratio. Cotton-seed meal, wheat bran, or alfalfa could be used for this purpose, but cotton-seed meal, if fed in quantity, contains so much protein that it makes, perhaps, too narrow a ration for the best results; besides, animals scour when fed cotton-seed meal and prickly pear alone, and if possible these should be fed in connection with some cured fodder.

In Bulletin 60 of the New Mexico Experiment Station a balanced ration of prickly pear is discussed and rations containing this feed are suggested. At the time this bulletin was written the coefficient of digestion for prickly pear had not been determined, and in calculating the rations its digestibility was assumed to be the same as that of green corn fodder.\* That the digestion

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\*See Bulletin 77, Office of Experiment Stations, United States Department of Agriculture, p. 82.



coefficient of prickly pear, calculated from the coefficient of green corn fodder, is very similar to that obtained from actual digestion experiments may be seen from the following table:

TABLE. 2.—*Total nutrients of prickly pear (Opuntia lindheimeri), the digestible nutrients as obtained by experiment, and the calculated digestible nutrients obtained by using the digestion coefficient of green corn fodder.*

| Name of nutrient.                                                                 | Protein.  | Fat.      | Nitrogen-free extract. | Fiber.    | Carbohydrates. |
|-----------------------------------------------------------------------------------|-----------|-----------|------------------------|-----------|----------------|
|                                                                                   | Per cent. | Per cent. | Per cent.              | Per cent. | Per cent.      |
| Prickly pear:                                                                     |           |           |                        |           |                |
| Composition.....                                                                  | 0.75      | 0.31      | 9.41                   | 2.61      | 2.01           |
| Digestible nutrients as determined.....                                           | 0.44      | 0.21      | 7.77                   | 1.09      | 8.86           |
| Digestible nutrients as calculated from data obtained with green corn fodder..... | 0.49      | 0.22      | 6.87                   | 1.76      | 8.63           |

From the foregoing table it may be seen that the coefficients of digestion of green corn fodder that were used for calculating the digestibility of prickly pear in the preparation of a balanced ration in Bulletin 60 are sufficiently close to allow the ration there given to remain unchanged.

The proteids of the prickly pear do not appear to be quite as digestible as those of green corn fodder, the fats are about the same in both, while the nitrogen-free extract is more for the prickly pear, the crude fiber is less, but the total digestible nutrients are about the same, being slightly in favor of prickly pear.

#### PLAN OF THE EXPERIMENTS.

##### THE ANIMALS USED.

Five different digestion experiments are included in this study. In all cases wild range steers from 2 to 3 years old were the animals selected. The steers being very wild were quite difficult to handle properly, but it seemed impossible to get tame steers and at the same time those accustomed to eating prickly pear. In fact, a gentle steer is practically unknown on the ranges. Plenty of milch cows were available, but were not used because of the difficulty of keeping separate the liquid and solid excreta. Both sheep and goats eat prickly pear, but none that could be used in this work

were found convenient; besides, steers were preferred, it being deemed more desirable to get the data for cattle, since they are fed this plant more extensively than are any other animals. Experience has shown that there may be a slight difference between the digestion coefficient obtained from sheep, goats, and cattle, yet for all practical purposes this factor may be assumed to be the same for all ruminants. Two steers were used in each of the experiments so as to minimize any difference due to individual animals or slight errors due to manipulation. It is usually customary to use two animals in this work; sometimes more are used, and of course the larger the number the more trustworthy should be the result.

#### THE DIFFERENT RATIONS USED.

The first experiment was conducted at San Antonio, Tex., in January, 1906. In this experiment the steers were fed prickly pear alone for about three weeks. During the last four days they were confined in stalls and all their feed and refuse were carefully weighed, the feces and urine being collected in a manner described later.

Experiments Nos. 2, 3, 4, and 5 were all conducted in the spring of 1907 at the Agricultural College of New Mexico. Grade Hereford steers were used in each experiment.

In experiment No. 2 prickly pear was fed alone, as in experiment No. 1 conducted at San Antonio the previous year.

In experiments Nos. 3 and 4 prickly pear was mixed with other feeding stuffs (alfalfa in experiment No. 3, cotton-seed meal in No. 4), to determine what effect, if any, these feeds might have on the digestibility of the prickly pear, or vice versa.

In experiment No. 5 the digestibility of the alfalfa, which was fed with prickly pear in experiment No. 3, was determined.

The digestibility of the cotton-seed meal when fed alone was not determined as was done with alfalfa, it being decided to accept the digestion coefficients secured by other experiments for this feed.

Summarized, the experiments were made to determine—

- (1) Digestibility of prickly pear (*Opuntia lindheimeri*).
- (2) Digestibility of prickly pear (*O. laevis*?).
- (3) Digestibility of prickly pear (*O. engelmannii cycloides*) and alfalfa.

(4) Digestibility of prickly pear (*O. engelmannii cycloides*) and cotton-seed meal.

(5) Digestibility of a fair quality of second-cut alfalfa.

#### DESCRIPTION OF THE STALLS.

A good idea of the stalls used in these experiments may be obtained from figure 1. They were made of proper length and breadth so that the steers could lie down comfortably, but not wide enough to permit them to turn around. The stalls used at the college were about  $8\frac{1}{4}$  feet long and 4 feet wide. Most of the floor, which had a slight inclination from both front and rear toward the center and to one side of the stall, was covered with thick rubber cloth. The inclination of the floor allowed all the urine to run to the middle of the stall, where it was caught in a galvanized iron trough and conducted to vessels outside the stall, as shown in the illustration. The urine trough ran the entire width of the stall near the center and just beneath the floor. A narrow 1-inch strip was nailed across the floor of the stall in such a manner as to prevent any liquid feces from running into the urine trough. The side and back walls of the stalls were lined with galvanized iron wherever there was any danger from spattering of feces. The feed trough was made perfectly tight, and so placed that the animals could eat with comfort and not waste their feed. The stalls were covered and placed in a position to make the animals as comfortable as possible.

#### THE FEEDING.

The preliminary feeding period which preceded the experiment proper was never less than seven days, usually more. In this time there was little possibility of any other food being left undigested in the animals' systems. The steers were then placed in the stalls and a weighed amount of the feed was given them twice each day, a sample being reserved for analysis each time before weighing. The prickly pear was first prepared by singeing the spines by means of a brush fire and chopping the singed stems into small pieces with a large knife or root chopper. A quantity of this feed was kept before the animals most of the time for a period of five days, the refuse being removed and weighed twice each day.

#### COLLECTING THE FECES.

After the preliminary period of a week or more the steers, which

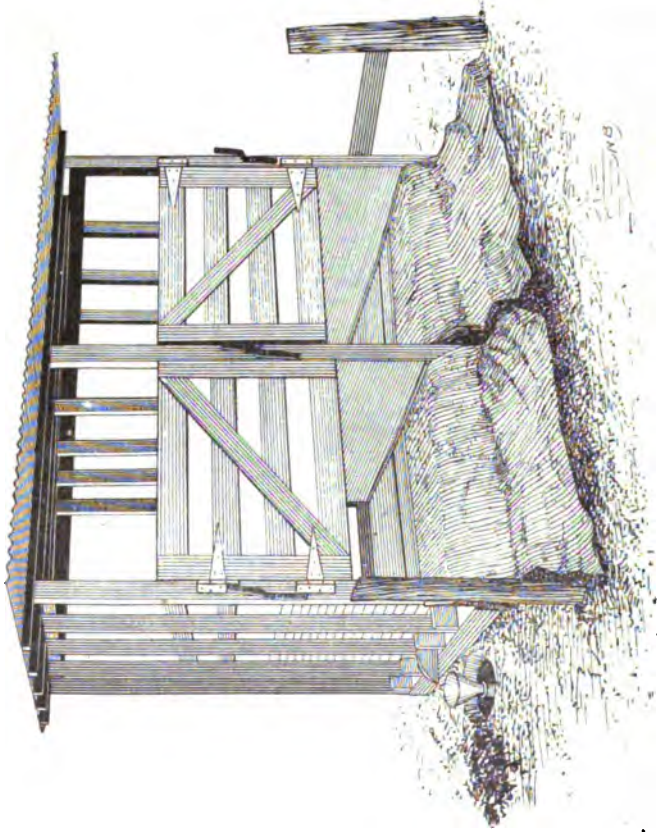


Fig. 3. The stalls used in experiments Nos. 2 to 5.

during this time had the run of a small inclosure, were placed in their stalls; but the feces were not collected for twenty-four hours afterwards. This was assumed to be the feces from the first feed that was weighed to them the day before. While this is an unsatisfactory method of determining the first weighed feed, it seemed the best that could be done, and it is believed that the error resulting, if any, was not large when the sum of the feces for the five days was taken. It is a difficult matter to mark the beginning of a digestion experiment with steers. In experiments of this kind with man or animals other than ruminants it is customary to use charcoal or some indigestible material of a different color from the feces, which will give a distinct line of separation between feces from weighed and unweighed food, but with the steers the marking of the weighed feed was not so simple. The experiment was tried of giving a small handful of weighed uncrushed corn as recommended in Minnesota Experiment Station Bulletin 99, but the method was found unsatisfactory in this instance because at times the corn did not appear for three or four days, and then it did not all come together.

Usually in digestion experiments with animals it is customary to fasten rubber bags to them by means of a harness to catch the excreta, but this was wholly impracticable with any range steers that could be obtained. Hence it was necessary to arrange the stalls as well as we could for the separation of feces and urine, and to keep an attendant constantly with the steers during the entire experiment. The work was made unusually difficult because the steers were wild and somewhat nervous all the time. Then, too, as the prickly pear caused diarrhea or "scouring" in the animals, extra care had to be exercised to prevent loss of feces from spattering and otherwise; but it is believed that with the precautions taken the method used was quite as satisfactory as the method of collecting in bags.

#### COLLECTING THE URINE.

Since the digestibility of a food is shown by the difference between the amount eaten and the amount undigested, all of which is found in the feces, there can be no object in collecting the urine when the digestibility of the food is all that is sought. This is therefore collected only when it is desired to know something of the metabolism of the nitrogen of the food. The solid matter of

urine other than the inorganic salts is principally urea and other highly nitrogenous compounds resulting from a waste of muscular and other nitrogenous tissue, the kidneys being the principal organs through which this waste is excreted from the body. The nitrogenous matter from the excess of digested proteids of the food may also be found in the urine.

In the experiments the urine was collected, weighed, and analyzed for the purpose of studying the income and outgo of nitrogen with the different feeds, in some of which the proteids were present in very small amounts, while in others the nutritive ratio was much narrower than that given by Wolff for oxen at rest in stalls. The results of this study of nitrogen metabolism are given in Table 17, and are discussed under "Income and Outgo of Nitrogen" in another part of this bulletin.

#### PREPARATION OF THE SAMPLES.

Samples of the feed and refuse were collected twice daily, and of feces and urine once each day. After a moisture determination had been made on the samples of feed and refuse for each day the dry matter from them all was mixed for one composite sample.

The daily samples of feces and urine were analyzed separately in all experiments except for the urine in experiment No. 1. In this instance one composite sample was made of all daily samples.

In collecting the samples of feed, refuse, and feces about 200 grams of the fresh material were taken in a large porcelain dish and placed in the hot New Mexico sun where it soon reached an air-dry condition. The dry material was then pulverized and was ready for the analyses, which were made according to the methods of the Association of Official Agricultural Chemists.

## REPORT OF THE EXPERIMENTS.

EXPERIMENT NO. 1.—DIGESTIBILITY OF PRICKLY PEAR (*Opuntia lindheimeri*.)

This experiment was conducted at the ranch of Mr. Alexander Sinclair, near San Antonio, Tex. This locality was selected because in that section the prickly pear grows much more luxuriantly than it does in the vicinity of the New Mexico Agricultural College, and cattle there are more accustomed to eating the plant than are the cattle of New Mexico; in fact, the steers that were fed at the college had to be trained to eat prickly pear, and in consequence ate not more than half the amount eaten by the Texas steers. Moreover, during part of the time, at least, what they did eat was little relished, except when fed in connection with some other feed.

In this experiment two 3-year-old steers, weighing about 800 pounds each, were used. They were fed for a preliminary period of ten days before being placed in the stalls. The experiment began at noon January 2, 1906, and continued until noon of January 6. The steers were placed in a barn with plenty of light and air, and were well protected from the cold. They remained in good condition during the entire experiment, except that they scoured quite badly, as animals always do on an exclusive prickly pear diet. The fact that these animals scoured is not surprising when one considers that in eating 100 pounds of prickly pear, the average daily ration during the five days, they consumed 2.95 pounds of inorganic matter or ash, which doubtless means more than twice this amount of salts more or less purgative in their character. The steers also obtained 86.4 pounds (or over 10 gallons) of water from 100 pounds of prickly pear, and this would doubtless aid in the purgative action. The water obtained from the feed was more than was drunk by the steers in experiment No. 5 where alfalfa alone was fed in which an average of only 48 pounds a day was drunk. The steers in experiment No. 1 took no water during the experiment except that obtained from the feed.

In Table 3 is given the composition of the composite sample made up of daily samples of the pear fed and refused during the four days the animals were in the stalls. There are also given analyses of daily samples of the feces from both steers. From these

figures with the weights of the dry matter in feed and feces have been calculated the data given in Table 4.

TABLE 3.—*Experiment No. 1—Composition of the prickly pear fed, of the refuse, and of the feces.*

[Nutrients reported water free]

|                               | Water.       | Ash.         | Pro-<br>tein. <sup>a</sup> | Fat. <sup>a</sup> | Crude<br>fiber. | Nitrogen-<br>free<br>extract. | Organic<br>matter. |
|-------------------------------|--------------|--------------|----------------------------|-------------------|-----------------|-------------------------------|--------------------|
|                               | Per<br>cent. | Per<br>cent. | Per<br>cent.               | Per<br>cent.      | Per<br>cent.    | Per cent.                     | Per<br>cent.       |
| Prickly pear, as fed.....     | 86.88        | 2.95         | 0.72                       | 0.19              | 1.77            | 8.02                          | 10.70              |
| Prickly pear, water free..... |              | 21.69        | 5.27                       | 1.42              | 13.00           | 58.62                         | 78.31              |
| Refuse, water free—           |              |              |                            |                   |                 |                               |                    |
| Steer No. 1.....              |              | 21.69        | 5.27                       | 1.42              | 13.00           | 58.62                         | 78.31              |
| Steer No. 2.....              |              | 21.69        | 5.27                       | 1.42              | 13.00           | 58.62                         | 78.31              |
| Feces steer No. 1—            |              |              |                            |                   |                 |                               |                    |
| First day.....                | 85.76        | 36.91        | 6.28                       | 1.51              | 22.94           | 32.36                         | 63.09              |
| Second day.....               | 85.50        | 42.64        | 6.28                       | 1.30              | 21.73           | 28.05                         | 57.36              |
| Third day.....                | 84.63        | 42.79        | 7.79                       | 1.57              | 19.38           | 28.47                         | 57.21              |
| Fourth day.....               | 86.65        | 42.34        | 5.97                       | 1.27              | 21.06           | 29.36                         | 57.66              |
| Feces steer No. 2—            |              |              |                            |                   |                 |                               |                    |
| First day.....                | 82.83        | 45.93        | 5.85                       | 1.24              | 21.46           | 25.52                         | 54.07              |
| Second day.....               | 81.39        | 45.33        | 6.40                       | 1.31              | 20.91           | 25.05                         | 54.67              |
| Third day.....                | 88.89        | 36.74        | 7.79                       | 1.36              | 19.82           | 34.29                         | 63.26              |
| Fourth day.....               | 87.62        | 35.82        | 5.58                       | 1.18              | 23.47           | 34.45                         | 64.68              |

<sup>a</sup> The words "protein" and "fat" are used here and elsewhere in this bulletin to denote, respectively, crude protein and ether extract.



TABLE 4.—*Weight of the feed, refuse, and feces in experiment No. 1, with the calculated digestion coefficients.*

## STEER NO. 1.

|                                       | Dry matter. | Ash.    | Protein. | Fat.   | Crude fiber. | Nitrogen free extract. | Organic matter. |
|---------------------------------------|-------------|---------|----------|--------|--------------|------------------------|-----------------|
|                                       | Grams.      | Grams.  | Grams.   | Grams. | Grams.       | Grams.                 | Grams.          |
| Total prickly pear fed .....          | 25,542.7    | 5,540.0 | 1,346.1  | 362.7  | 3,330.6      | 14,973.3               | 20,002.7        |
| Total prickly pear refused .....      | 441.8       | 95.7    | 23.3     | 6.3    | 57.4         | 258.6                  | 345.6           |
| Total prickly pear eaten .....        | 25,101.4    | 5,444.3 | 1,322.8  | 356.4  | 3,283.2      | 14,714.7               | 19,657.1        |
| Feces:                                |             |         |          |        |              |                        |                 |
| First day .....                       | 1,913.3     | 706.2   | 120.2    | 28.9   | 438.9        | 619.1                  | 1,207.1         |
| Second day .....                      | 1,546.2     | 659.3   | 97.1     | 20.1   | 336.0        | 433.7                  | 886.9           |
| Third day .....                       | 2,063.7     | 883.1   | 160.8    | 33.4   | 399.9        | 587.5                  | 1,180.6         |
| Fourth day .....                      | 2,730.1     | 1,155.9 | 168.0    | 34.7   | 575.0        | 801.5                  | 1,574.2         |
| Total feces dropped .....             | 8,253.3     | 3,404.5 | 545.1    | 116.1  | 1,749.8      | 2,441.8                | 4,848.8         |
| Digested .....                        | 16,848.1    | 2,039.8 | 781.7    | 240.3  | 1,513.4      | 12,272.9               | 14,808.3        |
| Coefficient of digestion (per ct.) .. | 67.12       | 37.46   | 59.08    | 67.42  | 41.31        | 53.40                  | 71.21           |

## STEER NO 2

|                                               |          |         |         |       |         |          |          |
|-----------------------------------------------|----------|---------|---------|-------|---------|----------|----------|
| Total prickly pear fed .....                  | 24,422.6 | 5,297.8 | 1,287.1 | 346.8 | 3,174.9 | 14,316.5 | 19,125.3 |
| Total prickly pear refused .....              | 849.4    | 192.9   | 46.9    | 12.6  | 115.6   | 521.6    | 696.7    |
| Total prickly pear eaten .....                | 23,533.2 | 5,104.4 | 1,240.2 | 334.2 | 3,059.3 | 13,794.9 | 18,428.6 |
| Feces:                                        |          |         |         |       |         |          |          |
| First day .....                               | 1,697.6  | 779.7   | 99.3    | 21.1  | 364.3   | 433.2    | 917.9    |
| Second day .....                              | 2,390.5  | 1,083.6 | 153.0   | 31.3  | 499.9   | 622.7    | 1,306.9  |
| Third day .....                               | 1,749.8  | 642.9   | 133.3   | 23.8  | 346.8   | 600.0    | 1,106.9  |
| Fourth day .....                              | 2,489.5  | 879.3   | 138.9   | 29.4  | 581.8   | 857.6    | 1,610.2  |
| Total feces dropped .....                     | 8,327.4  | 3,385.5 | 527.5   | 105.6 | 1,795.3 | 2,513.5  | 4,191.9  |
| Digested .....                                | 15,205.8 | 1,718.9 | 712.7   | 228.6 | 1,264.0 | 11,281.4 | 14,236.7 |
| Coefficient of digestion (per ct.) ..         | 64.61    | 33.67   | 57.47   | 68.38 | 41.32   | 81.78    | 77.03    |
| Average per cent digested by two steers ..... | 65.86    | 35.57   | 58.25   | 67.90 | 41.32   | 82.59    | 74.12    |

NOTE.—453.4 grams equal 1 pound.

The figures given above speak fairly well for the digestibility of the prickly pear. The coefficient for dry matter is equal to an average of that obtained from our best feeds.

This experiment shows that the digestion coefficient for the ash of prickly pear is low, but this was to be expected because of the large amount of ash always present in these plants. Animals assimilate more ash from prickly pear with the low digestion coefficient of this nutrient than they obtain from other feeds. For example, the ash assimilated from 100 pounds of prickly pear by steer No. 1 of this experiment amounts to 1.11 pounds; while steer No. 1 in experiment No. 5, where alfalfa alone was fed, assimilated only 0.63 pound from 15 pounds of alfalfa.

The digestibility of the other nutrients is found to compare very favorably with other standard feeds, the coefficient for nitrogen-free extract being unusually high.

#### EXPERIMENT NO. 2.—DIGESTIBILITY OF PRICKLY PEAR (*Opuntia laevis*?)

This experiment and the three following were all conducted with the same two steers. They were grade Herefords that had been grain fed and were ready for the market at the time the experiment was begun. This fact rendered them less satisfactory for feeding on prickly pear alone; and to make the matter worse the feeding was done in the spring, when many of the joints were young and least palatable to animals. In view of this fact the daily ration, amounting to only 53.52 pounds for steer No. 1, and 72.18 pounds for steer No. 2, was considerably short of enough for maintenance. The animals lost flesh rapidly on this ration, but unfortunately we can not say just how much, since they were not weighed after the experiment. However, by reference to Table 17, it may be seen that the excreted nitrogen during the five days was in excess of the nitrogen of the feed by 46.9 grams for steer No. 1 and 63.2 grams for steer No. 2, making a daily loss of 58.6 grams of proteids for steer No. 1 and of 79 grams for steer No. 2.

By referring to Table 5 it will be seen that both steers received much less than a maintenance ration. Steer No. 1 ate only 6.64 pounds of dry matter, when for maintenance he should have had 15.1 pounds. Steer No. 2 ate 9.36 pounds out of 16.7 pounds required, and the nutritive ratio of the dry matter was 1 to 33 for both steers.

The results of this experiment agree fairly well with those obtained at San Antonio in experiment No. 1, the greatest difference being in the amount of protein and fiber digested. The increased amount of fiber digested in this experiment might be explained by the fact that the plants were mostly young and succulent joints in which the fiber had not developed to such an extent from the more digestible hydrated cellulose. Steer No. 1 obtained 46.3 pounds of water from the prickly pear eaten. He drank in addition an average of 7.6 pounds daily. Steer No. 2 obtained 62.4 pounds of water from his feed and drank in addition 5.4 pounds.

TABLE 5.—*Experiment No. 2.—Composition of the prickly pear fed, of the refuse, and of the feces.*

[Nutrients reported water free.]

|                                                        | Water.    | Ash.      | Protein.  | Fat.      | Crude fiber. | Nitrogen-free extract | Organic matter. |
|--------------------------------------------------------|-----------|-----------|-----------|-----------|--------------|-----------------------|-----------------|
|                                                        | Per cent. | Per cent. | Per cent. | Per cent. | Per cent.    | Per cent.             | Per cent.       |
| Prickly pear fed.....                                  | 86.45     | 2.85      | 0.57      | 0.23      | 2.25         | 7.65                  | 10.70           |
| Prickly pear, water free.....                          | .....     | 31.05     | 4.22      | 1.71      | 16.61        | 56.41                 | 78.95           |
| Refuse, water free.....<br>Steer No. 1. Steer No. 2. { | .....     | 21.82     | 4.04      | 1.46      | 17.14        | 54.94                 | 78.18           |
| Feces of steer No. 1:                                  |           |           |           |           |              |                       |                 |
| First day.....                                         | 76.72     | 38.85     | 6.98      | 1.33      | 18.94        | 33.90                 | 61.15           |
| Second day.....                                        | 75.40     | 44.49     | 6.87      | 1.28      | 19.22        | 28.14                 | 55.51           |
| Third day.....                                         | 73.36     | 38.62     | 7.42      | 1.51      | 21.64        | 30.81                 | 61.38           |
| Fourth day.....                                        | 74.55     | 31.74     | 8.49      | 1.77      | 20.07        | 37.93                 | 68.26           |
| Fifth day.....                                         | 72.04     | 31.42     | 8.81      | 1.95      | 24.52        | 35.30                 | 68.58           |
| Feces of steer No. 2:                                  |           |           |           |           |              |                       |                 |
| First day.....                                         | 82.50     | 37.07     | 7.28      | 1.49      | 21.38        | 32.78                 | 62.93           |
| Second day.....                                        | 81.04     | 41.75     | 5.78      | 1.16      | 21.07        | 30.24                 | 58.25           |
| Third day.....                                         | 80.01     | 40.01     | 5.91      | 1.40      | 19.82        | 32.86                 | 59.99           |
| Fourth day.....                                        | 84.46     | 31.32     | 5.91      | 1.54      | 19.56        | 41.67                 | 68.68           |
| Fifth day.....                                         | 76.69     | 36.86     | 6.91      | 1.98      | 24.57        | 29.68                 | 63.14           |

TABLE 6.—*Weight of the feed, refuse, and feces in experiment No. 2, with the calculated digestion coefficients.*

## STEER NO. 1.

|                                    | Dry<br>matter. | Ash.    | Protein. | Fat.   | Crude<br>fiber. | Nitrogen<br>free<br>extract | Organic<br>matter. |
|------------------------------------|----------------|---------|----------|--------|-----------------|-----------------------------|--------------------|
|                                    | Grams.         | Grams.  | Grams.   | Grams. | Grams.          | Grams.                      | Grams.             |
| Total prickly pear fed.....        | 18,749.3       | 3,946.7 | 791.2    | 320.6  | 3,114.3         | 10,576.5                    | 14,802.6           |
| Total prickly pear refused.....    | 3,694.5        | 806.1   | 171.4    | 53.9   | 633.2           | 2,029.9                     | 2,888.4            |
| Total prickly pear eaten.....      | 15,054.8       | 3,140.6 | 619.8    | 266.7  | 2,481.1         | 8,546.6                     | 11,914.2           |
| Feces:                             |                |         |          |        |                 |                             |                    |
| First day.....                     | 912.6          | 354.5   | 63.7     | 12.1   | 172.8           | 309.5                       | 558.1              |
| Second day ..                      | 1,287.8        | 572.9   | 88.5     | 16.5   | 247.5           | 362.4                       | 714.9              |
| Third day.....                     | 690.0          | 266.5   | 51.2     | 10.4   | 149.3           | 212.6                       | 423.5              |
| Fourth day.....                    | 917.5          | 291.2   | 77.9     | 16.2   | 184.1           | 348.1                       | 626.3              |
| Fifth day.....                     | 1,322.1        | 434.3   | 94.1     | 27.0   | 339.0           | 487.7                       | 947.8              |
| Total feces dropped.....           | 5,190.0        | 1,919.4 | 375.4    | 82.2   | 1,092.7         | 1,720.3                     | 3,270.6            |
| Total digested.....                | 9,864.8        | 1,221.2 | 244.4    | 184.5  | 1,388.4         | 6,826.3                     | 8,643.6            |
| Coefficient of digestion (percent) | 65.52          | 38.88   | 39.43    | 69.18  | 55.96           | 79.87                       | 72.55              |

## STEER NO. 2.

|                                        |          |         |         |       |         |          |          |
|----------------------------------------|----------|---------|---------|-------|---------|----------|----------|
| Total prickly pear fed.....            | 23,753.8 | 5,000.2 | 1,002.4 | 406.2 | 3,945.5 | 13,399.5 | 18,753.6 |
| Total prickly pear refused.....        | 2,530.0  | 552.0   | 117.4   | 36.9  | 433.6   | 1,390.0  | 1,978.0  |
| Total prickly pear eaten.....          | 21,223.8 | 4,448.2 | 885.0   | 369.3 | 3,511.9 | 12,009.5 | 16,775.6 |
| Feces:                                 |          |         |         |       |         |          |          |
| First day.....                         | 1,564.5  | 576.3   | 113.2   | 23.2  | 332.3   | 509.5    | 978.2    |
| Second day....                         | 1,784.1  | 744.9   | 103.1   | 20.7  | 375.9   | 539.5    | 1,039.2  |
| Third day.....                         | 1,228.0  | 491.3   | 72.6    | 17.2  | 243.4   | 403.5    | 736.7    |
| Fourth day.....                        | 1,434.3  | 449.2   | 84.8    | 22.1  | 280.5   | 597.7    | 985.1    |
| Fifth day.....                         | 1,981.4  | 730.3   | 136.9   | 39.2  | 486.8   | 589.2    | 1,251.1  |
| Total feces dropped.....               | 7,982.3  | 2,992.0 | 510.6   | 122.4 | 1,718.9 | 2,638.4  | 4,990.3  |
| Total prickly pear digested.....       | 13,241.5 | 1,456.2 | 374.4   | 246.9 | 1,792.0 | 9,371.1  | 11,785.3 |
| Coefficient of digestion (per cent) .. | 62.40    | 32.74   | 42.31   | 68.86 | 51.02   | 78.03    | 70.12    |
| Average coefficient of digestion       | 63.96    | 35.81   | 40.87   | 69.02 | 53.99   | 78.95    | 71.39    |

EXPERIMENT NO. 3.—DIGESTIBILITY OF PRICKLY PEAR (*Opuntia engelmannii cycloides*) AND ALFALFA.

Since prickly pear will not furnish a balanced ration when fed alone, but requires some feed of a relatively high protein content as a supplement, the effect of alfalfa on the digestibility of the prickly pear has here been tried. Steer No. 1 was given an average of 4.5 pounds of alfalfa daily, while 4.72 pounds was given to steer No. 2. In addition they were given all the prickly pear they would eat, which was 42.16 pounds for steer No. 1, and 57.18 pounds for steer No. 2. The prickly pear used was *Opuntia engelmannii cycloides*, which is a larger stemmed plant than most of the native prickly pears, and the animals seemed to relish it better than they did *O. laevis*?, the variety used in the preceding experiment.

The results obtained in feeding this ration to steer No. 1 were for some unaccountable reason very unsatisfactory. The dry matter digested amounted to only 56.81 per cent and the ash to 16.87 per cent, while the protein coefficient was minus 16.54 per cent. This negative value for protein means that the protein of the feces amounted to more than that of the feed. Whether this unexpected result was due to blood or to cleavage products in the feces, we can not say. The percentage of nitrogen in the feces was unusually high, but duplicate analyses of these were made that checked within reasonable limits of working error. Only 29.92 per cent of the fiber was digested by this animal, but the amounts of fat, nitrogen-free extract, and organic matter seemed to compare favorably with the coefficients of these nutrients from the feed of steer No. 2. Assuming the digestibility of prickly pear fed in this experiment to be an average of the coefficients for the two varieties determined in experiments Nos. 1 and 2, we have by the use of this factor calculated the digestion coefficient of the alfalfa that constituted the other portion of the ration. The coefficients obtained for alfalfa with steer No. 1 are quite as unsatisfactory as were those obtained from this steer for prickly pear. They were all far below the normal digestion coefficients for this feeding stuff, the results for ash being minus 38.9 per cent. While the results obtained from steer No. 1 with this ration are all recorded in the following tables, it is very evident that the coefficients found can not be used in the calculation of rations of

either prickly pear or alfalfa. We have therefore omitted them from all averages.

With steer No. 2 the results show an increase in the digestibility of the nutrients of both feeds, and this is just what might be expected with this ration.

For a comparison of the digestion coefficients of prickly pear and alfalfa obtained in the following table with those of prickly pear obtained in the other experiments and of alfalfa obtained both here and at the other experiment stations, see Table 14.

TABLE 7.—*Experiment No. 3.—Composition of the prickly pear and alfalfa fed, of the refuse, and of the feces.*

[Nutrients reported water free.]

|                                | Water.    | Ash.      | Protein.  | Fat.      | Crude fiber. | Nitrogen-free extract. | Organic matter |
|--------------------------------|-----------|-----------|-----------|-----------|--------------|------------------------|----------------|
|                                | Per cent. | Per cent. | Per cent. | Per cent. | Per cent.    | Per cent.              | Per cent.      |
| Prickly pear, water free.....  | None.     | 18.75     | 2.98      | 1.48      | 12.22        | 64.57                  | 81.25          |
| Alfalfa, water free .....      | None.     | 10.09     | 14.09     | 2.07      | 32.28        | 41.47                  | 89.91          |
| Refuse of prickly pear, steers |           |           |           |           |              |                        |                |
| Nos. 1 and 2.....              |           | 18.75     | 2.98      | 1.48      | 12.22        | 64.57                  | 81.25          |
| Refuse of alfalfa, steers Nos. |           |           |           |           |              |                        |                |
| 1 and 2.....                   | None.     | None.     | None.     | None.     | None.        | None.                  | None.          |
| Feces of steer No. 1:          |           |           |           |           |              |                        |                |
| First day.....                 | 73.56     | 35.62     | 7.60      | 2.02      | 25.79        | 28.97                  | 64.38          |
| Second day.....                | 82.79     | 27.87     | 9.80      | 1.93      | 32.68        | 27.72                  | 72.13          |
| Third day.....                 | 80.89     | 29.46     | 9.42      | 2.18      | 20.62        | 38.32                  | 70.54          |
| Fourth day.....                | 80.10     | 26.85     | 9.01      | 1.87      | 28.00        | 34.27                  | 73.15          |
| Fifth day.....                 | 79.02     | 25.80     | 9.10      | 1.50      | 29.65        | 33.95                  | 74.20          |
| Feces of steer No. 2:          |           |           |           |           |              |                        |                |
| First day.....                 | 82.50     | 29.65     | 7.40      | 1.91      | 36.80        | 24.24                  | 70.35          |
| Second day.....                | 83.67     | 27.40     | 8.20      | 1.80      | 27.71        | 34.89                  | 72.60          |
| Third day.....                 | 80.88     | 28.71     | 8.24      | 1.82      | 26.00        | 35.23                  | 71.29          |
| Fourth day.....                | 83.13     | 23.84     | 7.13      | 1.76      | 29.18        | 38.09                  | 76.16          |
| Fifth day.....                 | 83.46     | 28.10     | 7.00      | 1.64      | 31.83        | 31.34                  | 71.90          |

TABLE 8.—*Weight of the feed, refuse and feces in Experiment No. 3, with calculated digestion coefficients of both feeds used and of each separately.*

STEER No. 1.

|                                                                                      | Dry<br>matter. | Ash.    | Protein. | Fat.   | Crude<br>fiber. | Nitrogen-<br>free<br>extract. | Organic<br>matter. |
|--------------------------------------------------------------------------------------|----------------|---------|----------|--------|-----------------|-------------------------------|--------------------|
|                                                                                      | Grams.         | Grams.  | Grams.   | Grams. | Grams.          | Grams.                        | Grams.             |
| Total prickly pear<br>fed .....                                                      | 33,994.7       | 6,374.0 | 1,012.0  | 53.1   | 4,154.1         | 21,950.4                      | 27,620.7           |
| Total prickly pear<br>refused .....                                                  | 14,236.6       | 2,669.4 | 424.3    | 210.7  | 1,739.7         | 9,192.6                       | 11,567.2           |
| Total prickly<br>pear eaten .....                                                    | 19,758.1       | 3,704.6 | 587.7    | 292.4  | 2,414.4         | 12,757.8                      | 15,053.5           |
| Total alfalfa fed...                                                                 | 9,685.6        | 977.3   | 1,364.7  | 200.5  | 3,126.5         | 4,016.6                       | 8,708.3            |
| Total alfalfa re-<br>fused .....                                                     | None           | None    | None     | None   | None            | None                          | None               |
| Total alfalfa<br>eaten .....                                                         | 9,685.6        | 977.3   | 1,364.7  | 200.5  | 3,126.5         | 4,016.6                       | 8,708.3            |
| <b>Feces:</b>                                                                        |                |         |          |        |                 |                               |                    |
| First day .....                                                                      | 2,164.9        | 771.1   | 164.5    | 43.7   | 558.3           | 427.3                         | 1,393.8            |
| Second day .....                                                                     | 2,592.2        | 722.4   | 254.0    | 50.0   | 847.1           | 718.7                         | 1,869.8            |
| Third day .....                                                                      | 2,062.0        | 607.5   | 191.2    | 45.0   | 425.2           | 790.1                         | 1,454.5            |
| Fourth day .....                                                                     | 2,980.0        | 800.1   | 268.5    | 55.7   | 834.4           | 1,021.3                       | 2,179.9            |
| Fifth day .....                                                                      | 3,085.5        | 776.2   | 273.8    | 45.1   | 892.0           | 1,021.4                       | 2,232.3            |
| Total feces<br>dropped .....                                                         | 12,807.6       | 3,677.3 | 1,155.0  | 239.5  | 3,537.0         | 4,178.8                       | 9,130.3            |
| Coefficient of di-<br>gestion of prick-<br>ly pear and alfal-<br>fa (per cent) ..... | 56.84          | 21.46   | 40.84    | 51.41  | 35.80           | 75.09                         | 61.57              |
| Total alfalfa un-<br>digested .....                                                  | 4,273.3        | 597.6   | 470.1    | 163.4  | 1,865.0         | 1,211.4                       | 3,675.8            |
| Total feces from<br>prickly pear .....                                               | 8,534.3        | 3,079.7 | 694.9    | 76.1   | 1,692.0         | 2,967.4                       | 5,454.5            |
| Total prickly pear<br>digested .....                                                 | 11,223.8       | —624.9  | —97.2    | 216.3  | 722.4           | 9,790.4                       | 9,599.0            |
| Coefficient of di-<br>gestion of prick-<br>ly pear (per cent)                        | 56.81          | —16.87  | —16.54   | 73.97  | 29.92           | 76.74                         | 63.09              |
| Coefficient of di-<br>gestion of alfal-<br>fa (per cent) a..                         | 39.35          | 38.90   | 29.76    | 26.54  | 26.65           | 57.04                         | 42.24              |

a. Calculated on the assumption that the coefficient of digestion of the prickly pear used in this experiment was an average of the two varieties fed in experiments Nos. 1 and 2.

## 30 . DIGESTIBILITY OF PRICKLY PEAR BY CATTLE

TABLE 8.—*Weight of the feed, refuse, and feces in Experiment No. 3, with calculated digestion coefficients of both feeds used and of each separately.*—Continued.

STEER NO. 2.

|                                                                                 | Dry<br>matter. | Ash.    | Protein. | Fat.   | Crude<br>fiber. | Nitrogen-<br>free<br>extract. | Organic<br>matter. |
|---------------------------------------------------------------------------------|----------------|---------|----------|--------|-----------------|-------------------------------|--------------------|
|                                                                                 | Grams.         | Grams.  | Grams.   | Grams. | Grams.          | Grams.                        | Grams.             |
| Total prickly pear<br>fed.....                                                  | 39,146.1       | 7,339.9 | 1,166.6  | 579.4  | 4,783.7         | 23,276.4                      | 31,806.2           |
| Total prickly pear<br>refused.....                                              | 12,033.3       | 2,256.2 | 358.6    | 178.1  | 1,470.6         | 7,769.9                       | 9,777.1            |
| Total prickly<br>pear eaten.....                                                | 27,112.8       | 5,083.7 | 808.0    | 401.3  | 3,313.2         | 17,506.5                      | 22,029.1           |
| Total alfalfa fed...                                                            | 10,157.3       | 1,024.9 | 1,431.2  | 210.2  | 3,278.8         | 4,212.2                       | 9,132.4            |
| Total alfalfa re-<br>fused.....                                                 | None           | None.   | None.    | None.  | None.           | None.                         | None.              |
| Total alfalfa<br>eaten.....                                                     | 10,157.3       | 1,024.9 | 1,431.2  | 210.2  | 3,278.8         | 4,212.2                       | 9,132.4            |
| Feces:                                                                          |                |         |          |        |                 |                               |                    |
| First day.....                                                                  | 1,948.5        | 577.7   | 144.2    | 37.2   | 717.0           | 472.4                         | 1,370.7            |
| Second day....                                                                  | 2,604.6        | 713.7   | 213.6    | 46.9   | 721.7           | 908.7                         | 1,890.9            |
| Third day.....                                                                  | 2,820.2        | 809.7   | 232.4    | 51.3   | 733.3           | 993.5                         | 2,010.5            |
| Fourth day....                                                                  | 3,188.4        | 760.1   | 227.3    | 56.1   | 930.4           | 1,214.5                       | 2,428.3            |
| Fifth day.....                                                                  | 2,160.1        | 607.0   | 153.2    | 35.4   | 687.6           | 676.9                         | 1,543.1            |
| Total feces<br>dropped....                                                      | 12,721.8       | 3,468.2 | 970.7    | 226.9  | 3,790.0         | 4,266.0                       | 9,253.5            |
| Coefficient of di-<br>gestion of prickly<br>pear and alfalfa<br>(per cent)..... | 65.87          | 43.22   | 56.65    | 62.89  | 42.51           | 80.36                         | 70.34              |
| Total alfalfa undi-<br>gested.....                                              | 4,481.3        | 626.7   | 493.0    | 147.2  | 1,955.8         | 1,270.1                       | 3,854.8            |
| Total feces from<br>prickly pear.....                                           | 8,240.5        | 2,841.5 | 477.7    | 79.7   | 1,834.2         | 2,995.6                       | 5,398.7            |
| Total prickly pear<br>digested.....                                             | 18,872.3       | 2,242.2 | 189.3    | 321.6  | 1,479.0         | 14,510.9                      | 16,630.4           |
| Coefficient of di-<br>gestion of prickly<br>pear (per cent)...                  | 69.61          | 44.11   | 40.88    | 80.14  | 44.63           | 82.88                         | 75.49              |
| Coefficient of di-<br>gestion of alfalfa<br>(per cent) a.....                   | 68.41          | 80.59   | 60.65    | 53.28  | 37.29           | 78.65                         | 64.38              |

a Calculated on the assumption that the coefficient of digestion of the prickly pear used in this experiment was an average of the two varieties fed in experiments Nos. 1 and 2.



EXPERIMENT NO. 4.—DIGESTIBILITY OF PRICKLY PEAR (*Opuntia engelmannii cycloides*) AND COTTON-SEED MEAL.

In the prickly-pear region of Texas a ration consisting of this feeding stuff with cotton-seed meal is very common. It is customary and better to give the cattle either the run of a dry grass pasture or some coarse feed in connection with this ration, as it will serve the double purpose of widening the too narrow ration produced from too much cotton-seed meal and tend to check the scouring which results from the use of these two feeds alone. Bulletin 74 of the Bureau of Plant Industry, United States Department of Agriculture, gives a number of rations as used by Texas stockmen and dairymen made up of prickly pear and cotton-seed meal in varying amounts that were usually fed together with other feeds. However, in the ration used in this digestion experiment prickly pear and cotton-seed meal alone were used, because it was desired not only to determine the coefficient of digestion of the ration of the two when fed together but also to use the weights obtained for a calculation of the coefficient of digestion of cotton-seed meal, and these would have been complicated by the addition of other feeds to the ration.

Steer No. 1 ate an average of 4.78 pounds of cotton-seed meal and 37.28 pounds of prickly pear daily. This made only 14.14 pounds of dry matter, which was about 1 pound short of a maintenance ration of dry matter; but the proteids were in excess of the amount required for maintenance by more than a pound, and while the carbohydrates were a trifle short, the excess of both proteids and fat made the total nutrients more than the amount required for maintenance. The nutritive ratio of the feed for this steer was 1 to 4.49, and he gained 1,551.9 grams of proteids in the five days.

Steer No. 2 ate a daily average of 4.99 pounds of cotton-seed meal and 47.04 pounds of prickly pear. This gave him 17.35 pounds, or nearly one pound more than a maintenance ration, of dry matter which contained a slight excess of all the nutrients. The nutritive ratio of his feed was 1 to 5.52. He gained for the five days 1,262.5 grams of protein.

The digestion coefficient for the two steers agreed very closely, but while the coefficient for the protein of cotton-seed meal and of cotton-seed meal with prickly pear was about what might be ex-

pected, the coefficient for the protein in the prickly pear was a minus quantity to about the same degree for both steers. This might be attributed to several causes. It may have been because the composite sample of pear used for analyses did not contain sufficient proteids to be representative of the prickly pear fed. It had only 2.59 per cent of protein, while an average of the five samples of this species recorded in Bulletin 60 of the New Mexico Experiment Station had 3.99 per cent, and an average of all prickly pears contained 4.47 per cent protein in the air-dry material. It is barely possible also that some error may have been introduced here by hairs from the shedding animal getting into the feces. It is also possible that it resulted from a larger amount of metabolic products formed from a feed like cotton-seed meal with its high protein content. Steer No. 1, for example, got hardly 1 pound of protein from the prickly pear during the five days, but obtained nearly 10.5 pounds from the cotton-seed meal; and the large amount of protein from the latter source may have increased the metabolic nitrogen in the feces and thus made it appear that the feces from the prickly pear contained more protein than did the feed, when in reality it may have been due in part at least to cleavage products resulting from the protein of the cotton-seed meal fed.

As a further attempt to explain these negative results Professor Spillman has suggested the very probable theory that it resulted from the reduced digestibility of the protein of the cotton-seed meal, due to the laxative action of the prickly pear forcing the other feed from the digestive tract before its protein, which digests slowly, had been thoroughly acted upon, but not before the easily digested carbohydrates had been more completely assimilated. Since cotton-seed meal is a substance rich in protein and the prickly pear is very poor in this ingredient, a very slight reduction of the digestion coefficient of the former would and did result in an apparent negative result for the latter.

The average of three digestion coefficients for cotton-seed meal as given in Bulletin 77 of the Office of Experiment Stations, United States Department of Agriculture, was used in calculating these coefficients. Since the cotton-seed meal used in this experiment was adulterated with hulls, as may be seen from the crude-fiber analyses, it may be that the figures from the above bulletin did not represent the coefficients for the meal used in the experiment. If,

however, we assume the digestibility of prickly pear fed to be the same as that obtained in previous experiments, and calculate the coefficients of digestion for the nutrients of cotton-seed meal accordingly. we find them somewhat similar to those given in Bulletin 77. It is interesting to note that both of our calculations show over 100 per cent of the fat digested, which agrees with some of the results recorded in the above bulletin, and substantiates also the statement made by Jordan in his work on "The Feeding of Animals" that "pure vegetable fats and oils are quite completely emulsified and absorbed" by animals.

TABLE NO. 9.—*Experiment No. 4.—Composition of the prickly pear and cotton-seed meal fed, of the refuse, and of the feces.*

[Nutrients reported water free.]

|                                                         | Water.       | Ash          | Pro-<br>tein. | Fat.         | Crude<br>fiber. | Nitro-<br>gen-<br>free<br>ex-<br>tract. | Or-<br>ganic<br>mat-<br>ter. |
|---------------------------------------------------------|--------------|--------------|---------------|--------------|-----------------|-----------------------------------------|------------------------------|
|                                                         | Per<br>cent. | Per<br>cent. | Per<br>cent.  | Per<br>cent. | Per<br>cent.    | Per<br>cent.                            | Per<br>cent.                 |
| Prickly pear, water free.....                           | 72.97        | 21.74        | 2.59          | 2.08         | 11.44           | 62.20                                   | 78.26                        |
| Cotton-seed meal.....                                   | 5.09         | 6.68         | 44.25         | 10.02        | 11.02           | 28.03                                   | 93.32                        |
| Refuse of prickly pear, steer<br>No. 1.....             |              | 21.89        | 2.85          | 1.25         | 12.26           | 61.75                                   | 78.11                        |
| Refuse of prickly pear, steer<br>No. 2.....             |              | 24.87        | 2.85          | 1.51         | 11.38           | 59.89                                   | 75.13                        |
| Refuse of cotton-seed meal,<br>steers Nos. 1 and 2..... |              | 6.68         | 44.25         | 10.02        | 11.02           | 28.03                                   | 93.32                        |
| Feces of steer No. 1:                                   |              |              |               |              |                 |                                         |                              |
| First day.....                                          | 77.53        | 30.45        | 13.09         | 1.28         | 19.13           | 36.06                                   | 69.55                        |
| Second day.....                                         | 82.51        | 30.85        | 12.85         | 1.55         | 18.00           | 36.75                                   | 69.15                        |
| Third day.....                                          | 92.06        | 31.76        | 12.92         | 1.18         | 18.12           | 36.02                                   | 68.24                        |
| Fourth day.....                                         | 82.63        | 34.82        | 12.14         | 1.13         | 20.14           | 31.77                                   | 65.18                        |
| Fifth day.....                                          | 79.58        | 35.09        | 11.39         | 1.03         | 19.83           | 32.67                                   | 64.91                        |
| Feces of steer No. 2:                                   |              |              |               |              |                 |                                         |                              |
| First day.....                                          | 81.68        | 26.21        | 14.76         | 1.71         | 21.68           | 35.70                                   | 73.79                        |
| Second day.....                                         | 81.94        | 30.69        | 13.38         | 1.29         | 19.93           | 34.71                                   | 69.31                        |
| Third day.....                                          | 84.13        | 31.78        | 14.22         | .97          | 16.93           | 36.10                                   | 68.22                        |
| Fourth day.....                                         | 82.75        | 36.10        | 9.96          | 1.05         | 22.04           | 30.86                                   | 63.90                        |
| Fifth day.....                                          | 85.15        | 34.70        | 9.86          | 1.06         | 19.45           | 34.93                                   | 65.30                        |

TABLE NO. 10.—*Weight of the feed, refuse, and feces in Experiment No. 4, with calculated digestion coefficients of both feeds used and of each separately.*  
STEER NO. 1.

|                                                                               | Dry matter. | Ash.    | Protein. | Fat.    | Crude fiber. | Nitrogen-free extract. | Organic matter. |
|-------------------------------------------------------------------------------|-------------|---------|----------|---------|--------------|------------------------|-----------------|
|                                                                               | Grams.      | Grams.  | Grams.   | Grams.  | Grams.       | Grams.                 | Grams.          |
| Total prickly pear fed.....                                                   | 29,722.2    | 6,461.6 | 769.8    | 603.4   | 3,400.2      | 18,497.2               | 23,260.6        |
| Total prickly pear refused.....                                               | 7,964.5     | 1,743.4 | 227.0    | 99.6    | 976.4        | 4,918.1                | 6,221.1         |
| Total prickly pear eaten.....                                                 | 21,757.7    | 4,718.2 | 542.8    | 503.8   | 2,423.8      | 3,569.1                | 17,039.5        |
| Total cotton-seed meal fed.....                                               | 10,758.0    | 718.6   | 4,760.4  | 1,078.0 | 1,185.5      | 3,015.5                | 10,039.4        |
| Total cotton-seed meal refused.....                                           | 469.8       | 31.4    | 207.9    | 47.1    | 51.8         | 131.6                  | 438.4           |
| Total cotton-seed meal eaten.....                                             | 10,288.2    | 687.2   | 4,552.5  | 1,030.9 | 1,133.33     | 2,883.9                | 9,601.0         |
| Feces:                                                                        |             |         |          |         |              |                        |                 |
| First day.....                                                                | 2,033.5     | 619.2   | 266.2    | 26.0    | 389.0        | 733.1                  | 1,414.3         |
| Second day.....                                                               | 2,436.8     | 751.8   | 313.1    | 37.8    | 438.6        | 895.5                  | 1,685.0         |
| Third day.....                                                                | 1,863.7     | 591.9   | 240.8    | 22.0    | 327.7        | 671.3                  | 1,271.8         |
| Fourth day.....                                                               | 1,544.2     | 537.7   | 187.5    | 17.4    | 311.0        | 490.6                  | 1,006.5         |
| Fifth day.....                                                                | 2,550.5     | 895.0   | 290.2    | 26.3    | 505.8        | 833.2                  | 1,655.5         |
| Total feces dropped.....                                                      | 10,428.7    | 3,395.6 | 1,297.8  | 129.5   | 1,982.1      | 3,623.7                | 7,033.1         |
| Coefficient of digestion of prickly pear and cotton-seed meal (per cent)..... | 67.46       | 39.03   | 74.53    | 91.56   | 44.28        | 77.97                  | 73.60           |
| Total cotton-seed meal undigested.....                                        | 2,705.8     | 524.3   | 528.1    | 69.1    | 504.3        | 1,136.3                | 2,294.6         |
| Total feces from prickly pear a.....                                          | 7,722.9     | 2,871.3 | 769.7    | 60.4    | 1,477.8      | 2,487.4                | 4,738.5         |
| Total prickly pear digested.....                                              | 14,034.8    | 1,846.9 | 226.90   | 143.4   | 946.8        | 11,081.7               | 12,301.0        |
| Coefficient of digestion of prickly pear (per cent).....                      | 64.50       | 39.01   | 41.8     | 88.08   | 39.03        | 81.67                  | 72.19           |
| Coefficient of digestion of cotton-seed meal (per cent) b.....                | 72.84       | 47.42   | 77.51    | 102.7   | 37.04        | 64.83                  | 75.09           |

a Calculated on the assumption that the digestibility of this variety of cactus was the average of the two fed in Experiments Nos. 1 and 2.

b Coefficient of digestion for cotton-seed meal used in these calculations was taken from Bulletin 77. Office of Experiment Stations, U. S. Dept. of Agriculture.

TABLE NO. 10.—*Weight of the feed, refuse, and feces in Experiment No. 4, with calculated digestion coefficients of both feeds used and of each separately—Continued.*

STEER NO. 2

|                                                                                | Dry matter. | Ash.    | Protein. | Fat.    | Crude fiber. | Nitrogen-free extract. | Organic matter. |
|--------------------------------------------------------------------------------|-------------|---------|----------|---------|--------------|------------------------|-----------------|
|                                                                                | Grams.      | Grams.  | Grams.   | Grams.  | Grams.       | Grams.                 | Grams.          |
| Total prickly pear fed .....                                                   | 35,878.3    | 7,799.9 | 929.2    | 728.3   | 4,104.5      | 22,316.4               | 28,078.         |
| Total prickly pear refused .....                                               | 7,279.1     | 1,810.3 | 207.5    | 109.9   | 828.4        | 4,323.0                | 5,468.8         |
| Total prickly pear eaten .....                                                 | 28,599.2    | 5,988.6 | 721.7    | 618.4   | 3,276.1      | 17,993.4               | 22,609.6        |
| Total cotton-seed meal fed .....                                               | 10,758.0    | 718.6   | 4,780.4  | 1,078.0 | 1,185.5      | 3,015.6                | 10,039.5        |
| Total cotton-seed meal refused .....                                           | 20.9        | 1.4     | 9.2      | 2.1     | 2.3          | 5.9                    | 19.5            |
| Total cotton-seed meal eaten .....                                             | 10,737.1    | 717.2   | 4,751.2  | 1,075.9 | 1,183.2      | 3,009.7                | 10,020.0        |
| Feces:                                                                         |             |         |          |         |              |                        |                 |
| First day .....                                                                | 1,296.1     | 339.7   | 191.3    | 22.2    | 280.2        | 462.7                  | 956.4           |
| Second day .....                                                               | 2,975.4     | 915.2   | 398.1    | 38.4    | 593.0        | 1,032.7                | 2,062.2         |
| Third day .....                                                                | 2,487.6     | 790.6   | 353.7    | 24.1    | 421.2        | 898.0                  | 1,697.0         |
| Fourth day .....                                                               | 3,073.1     | 1,109.4 | 305.8    | 32.3    | 677.3        | 948.3                  | 1,963.7         |
| Fifth day .....                                                                | 2,690.1     | 933.5   | 265.2    | 28.5    | 523.2        | 939.7                  | 1,756.6         |
| Total feces dropped .....                                                      | 12,522.3    | 4,088.4 | 1,514.1  | 145.5   | 2,494.9      | 4,281.4                | 8,435.9         |
| Coefficient of digestion of prickly pear and cotton-seed meal (per cent) ..... | 68.17       | 39.05   | 72.33    | 91.41   | 44.05        | 77.97                  | 74.16           |
| Average coefficient of digestion of prickly pear and cotton seed meal .....    | 67.82       | 39.04   | 73.43    | 91.49   | 44.17        | 77.97                  | 73.88           |
| Total cotton-seed meal undigested .....                                        | 2,823.9     | 547.2   | 551.1    | 72.1    | 526.5        | 1,185.8                | 2,394.8         |
| Total feces from prickly pear a .....                                          | 9,698.4     | 3,539.2 | 963.0    | 73.4    | 1,968.4      | 3,096.6                | 6,041.1         |
| Total prickly pear digested .....                                              | 18,900.8    | 2,449.4 | 241.3    | 545.0   | 1,307.7      | 14,897.8               | 16,568.5        |
| Coefficient of digestion of prickly pear (per cent) .....                      | 66.68       | 40.90   | 34.82    | 68.13   | 39.92        | 82.70                  | 73.28           |
| Average coefficient of digestion of prickly pear (per cent) .....              | 65.29       | 39.96   | 32.31    | 68.11   | 39.48        | 82.23                  | 72.74           |
| Coefficient of digestion of cotton-seed meal (per cent) b .....                | 76.88       | 67.22   | 69.89    | 104.6   | 34.06        | 72.71                  | 77.28           |

a Calculated on the assumption that the digestibility of this variety of cactus was the average of the two fed in Experiments Nos. 1 and 2.

b Coefficient of digestion for cotton-seed meal used in these calculations was taken from Bulletin 77, Office of Experiment Stations, U. S. Dept. of Agriculture.

EXPERIMENT NO. 5.—DIGESTIBILITY OF A FAIR QUALITY OF SECOND-CUT ALFALFA.

This experiment was made to determine the digestion coefficients of the alfalfa that was used in experiment No. 3. The results are given in Table 12, from which it will be seen that the coefficients obtained in this experiment are about the same as those determined at other experiment stations. For some of the nutrients the coefficient is somewhat less than was obtained elsewhere. This may be accounted for by the fact that the hay used had lost a considerable proportion of its leaves in curing, and the Colorado Experiment Station has shown that these are the most digestible portions of the plant.

The dry matter eaten per day was somewhat less than a maintenance ration. The proteids were far in excess of the amount required, yet steer No. 2 lost, and steer No. 1 gained only a small amount of this nutrient, which shows that the excess of proteids was evidently used to serve the function of carbohydrates.

TABLE 11.—*Experiment No. 5—Composition of the alfalfa fed, of the refuse, and of the feces.*

[Nutrients reported water free.]

|                                      | Water.    | Ash.      | Protein.  | Fat.      | Crude fiber. | Nitrogen-free extract. | Organic matter.. |
|--------------------------------------|-----------|-----------|-----------|-----------|--------------|------------------------|------------------|
|                                      | Per cent. | Per cent. | Per cent. | Per cent. | Per cent.    | Per cent.              | Per cent.        |
| Alfalfa as fed.....                  | 5.09      | 9.58      | 13.37     | 1.96      | 30.64        | 39.36                  | 85.33            |
| Alfalfa, water free.....             |           | 10.09     | 14.09     | 2.07      | 32.28        | 41.47                  | 89.91            |
| Refuse, water free, steer No. 1..... |           | 10.09     | 14.09     | 2.07      | 32.28        | 41.47                  | 89.91            |
| Refuse, water free, steer No. 2..... |           | 10.09     | 14.09     | 2.07      | 32.28        | 41.47                  | 89.91            |
| Feces of steer No. 1:                |           |           |           |           |              |                        |                  |
| First day.....                       | 74.27     | 13.31     | 11.50     | 2.17      | 44.52        | 28.50                  | 86.69            |
| Second day.....                      | 78.09     | 11.35     | 10.53     | 2.11      | 42.73        | 33.28                  | 86.65            |
| Third day.....                       | 75.75     | 14.11     | 10.68     | 2.52      | 45.06        | 27.63                  | 85.89            |
| Fourth day.....                      | 78.98     | 15.80     | 10.67     | 3.00      | 41.19        | 29.34                  | 84.20            |
| Fifth day.....                       | 77.24     | 10.65     | 11.74     | 3.16      | 42.02        | 32.53                  | 89.45            |
| Feces of steer No. 2:                |           |           |           |           |              |                        |                  |
| First day.....                       | 84.87     | 16.50     | 11.57     | 2.26      | 43.68        | 25.90                  | 83.50            |
| Second day.....                      | 88.53     | 13.19     | 10.72     | 3.18      | 46.67        | 26.24                  | 86.81            |
| Third day.....                       | 80.97     | 15.56     | 10.63     | 3.37      | 42.56        | 27.88                  | 84.44            |
| Fourth day.....                      | 81.82     | 16.06     | 11.57     | 3.51      | 43.37        | 25.49                  | 83.94            |
| Fifth day.....                       | 74.99     | 13.61     | 10.63     | 3.36      | 46.54        | 25.86                  | 86.39            |

# DIGESTIBILITY OF PRICKLY PEAR BY CATTLE

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TABLE 12.—*Weight of the feed, refuse, and feces in experiment No. 5, with the calculated digestion coefficient.*

STEER NO. 1.

|                                    | Dry matter. | Ash.    | Protein. | Fat.   | Crude fiber. | Nitrogen-free extract. | Organic matter. |
|------------------------------------|-------------|---------|----------|--------|--------------|------------------------|-----------------|
|                                    | Grams.      | Grams.  | Grams.   | Grams. | Grams.       | Grams.                 | Grams.          |
| Total alfalfa fed...               | 32,274.1    | 3,256.5 | 4,547.4  | 668.1  | 10,418.1     | 13,384.0               | 29,017.6        |
| Total refused.....                 | 121.1       | 12.2    | 17.1     | 2.5    | 39.1         | 29.1                   | 87.8            |
| Total eaten                        | 32,153.0    | 3,244.3 | 4,530.3  | 665.6  | 10,479.0     | 13,354.9               | 28,929.8        |
| Feces:                             |             |         |          |        |              |                        |                 |
| First day.....                     | 2,162.1     | 287.8   | 248.6    | 46.9   | 962.6        | 616.2                  | 1,874.3         |
| Second day....                     | 2,962.4     | 335.1   | 310.9    | 62.3   | 1,261.6      | 982.5                  | 2,617.3         |
| Third day.....                     | 2,974.3     | 414.0   | 313.4    | 73.9   | 1,322.2      | 810.8                  | 2,520.3         |
| Fourth day....                     | 2,979.6     | 470.8   | 317.9    | 89.4   | 1,227.3      | 874.2                  | 2,508.8         |
| Fifth day.....                     | 2,981.6     | 314.6   | 350.0    | 94.2   | 1,252.9      | 969.9                  | 2,667.0         |
| Total feces dropped....            | 14,010.0    | 1,822.3 | 1,510.8  | 366.7  | 6,026.6      | 4,253.6                | 12,187.7        |
| Total digested.....                | 18,143.0    | 1,422.0 | 2,989.5  | 298.9  | 4,452.4      | 9,101.3                | 16,742.1        |
| Coefficient of digestion (percent) | 56.43       | 43.83   | 65.99    | 44.91  | 42.49        | 68.15                  | 57.87           |

STEER NO. 2.

|                                    |          |         |         |       |          |          |          |
|------------------------------------|----------|---------|---------|-------|----------|----------|----------|
| Total alfalfa fed...               | 32,274.1 | 3,256.5 | 4,547.4 | 668.1 | 10,418.1 | 13,384.0 | 29,017.6 |
| Total refused.....                 | None.    | None.   | None.   | None  | None.    | None.    | None.    |
| Total eaten..                      | 32,274.1 | 3,256.5 | 4,547.4 | 668.1 | 10,418.1 | 13,384.0 | 29,017.6 |
| Feces:                             |          |         |         |       |          |          |          |
| First day.....                     | 2,258.2  | 364.7   | 261.3   | 51.0  | 986.4    | 594.8    | 1,893.5  |
| Second day....                     | 1,947.1  | 256.8   | 208.7   | 61.9  | 908.7    | 511.0    | 1,690.3  |
| Third day.....                     | 2,816.4  | 438.2   | 299.4   | 94.9  | 1,198.7  | 785.2    | 2,378.2  |
| Fourth day....                     | 3,245.1  | 500.1   | 375.5   | 113.9 | 1,407.4  | 848.2    | 2,746.0  |
| Fifth day.....                     | 4,150.4  | 564.9   | 441.2   | 139.5 | 1,931.6  | 1,073.2  | 3,565.5  |
| Total feces dropped....            | 14,417.2 | 2,124.7 | 1,586.1 | 461.2 | 6,432.8  | 3,812.4  | 12,292.5 |
| Total digested.....                | 17,856.9 | 1,131.8 | 2,961.3 | 206.9 | 3,985.3  | 9,571.6  | 16,725.1 |
| Coefficient of digestion (percent) | 55.33    | 34.75   | 65.12   | 30.97 | 38.20    | 71.62    | 57.63    |
| Average coefficient of digestion.  | 55.88    | 39.29   | 65.56   | 37.94 | 40.35    | 69.84    | 57.75    |

EFFECT OF PRICKLY PEAR ON THE DIGESTIBILITY OF OTHER FEED-  
ING STUFFS.

From Table 13 it may be seen that in feeding a mixed ration of prickly pear and alfalfa, or prickly pear and cotton-seed meal, the general effect is to increase the digestibility of all three feeds. This table shows an increase in the digestible dry matter of all three, and with some exception there is an increase in the digestibility of the nutrients in them all.

If the ration of prickly pear will increase the digestibility of all feeding stuffs, as it apparently has that of alfalfa and cotton-seed meal, then this feed has a greater value than is shown by its own digestible nutrients. The probabilities are that the addition of this green and succulent feed to any dry feeding stuff will increase the digestibility of both.

TABLE 13.—*Average digestibility of prickly pear, alfalfa, and cotton-seed meal, and of a mixed ration of alfalfa and prickly pear, and cotton-seed meal and prickly pear.*

|                                           | Dry<br>mat-<br>ter. | Ash.         | Pro-<br>tein. | Fat.         | Crude<br>fiber. | Nitro-<br>gen-<br>free<br>ex-<br>tract. | Or-<br>ganic<br>mat-<br>ter. |
|-------------------------------------------|---------------------|--------------|---------------|--------------|-----------------|-----------------------------------------|------------------------------|
|                                           | Per<br>cent.        | Per<br>cent. | Per<br>cent.  | Per<br>cent. | Per<br>cent.    | Per<br>cent.                            | Per<br>cent.                 |
| Prickly pear alone.....                   | 64.91               | 35.69        | 49.56         | 68.46        | 47.66           | 80.77                                   | 72.76                        |
| Alfalfa alone.....                        | 55.88               | 39.29        | 65.56         | 37.94        | 40.35           | 69.84                                   | 57.75                        |
| Cotton-seed meal alone.....               | 73.70               | 23.70        | 88.40         | 93.30        | 55.50           | 60.60                                   | 76.10                        |
| Alfalfa and prickly pear.....             | 68.41               | 40.59        | 60.65         | 52.28        | 37.27           | 78.65                                   | 64.38                        |
| Cotton-seed meal and prickly<br>pear..... | 74.86               | 57.32        | 73.70         | 103.70       | 35.55           | 68.77                                   | 76.19                        |



TABLE 14.—Summary of all digestion coefficients obtained in these Experiments, together with some coefficients of alfalfa and cotton-seed meal as determined elsewhere.

| Feed.                                                                         | Steer No. | Dry matter. | Ash.    | Protein. | Fat.    | Crude fiber. | Nitrogen-free extract. | Organic matter. |
|-------------------------------------------------------------------------------|-----------|-------------|---------|----------|---------|--------------|------------------------|-----------------|
|                                                                               |           | Per ct.     | Per ct. | Per ct.  | Per ct. | Per ct.      | Per ct.                | Per ct.         |
| Prickly Pear ( <i>Opuntia lindheimeri</i> ) .....                             |           | 67.12       | 37.46   | 59.03    | 67.42   | 41.31        | 83.40                  | 71.21           |
| Do .....                                                                      | 2         | 64.61       | 33.67   | 57.47    | 63.38   | 41.32        | 81.78                  | 77.03           |
| Average .....                                                                 |           | 65.86       | 35.57   | 58.25    | 67.90   | 41.32        | 82.59                  | 74.12           |
| Prickly pear ( <i>O. laetis</i> ) ..                                          | 1         | 66.52       | 38.88   | 39.43    | 69.13   | 55.96        | 79.87                  | 72.55           |
| Do .....                                                                      | 2         | 62.40       | 82.74   | 42.31    | 68.86   | 51.02        | 78.03                  | 70.12           |
| Average .....                                                                 |           | 63.96       | 35.81   | 40.87    | 69.02   | 53.99        | 78.95                  | 71.39           |
| Average of both above averages .....                                          |           | 64.91       | 35.69   | 49.56    | 68.46   | 47.66        | 80.77                  | 72.76           |
| Prickly pear, calculated from feed of prickly pear and alfalfa .....          | 1a        | 56.81       | -16.87  | -16.54   | 73.97   | 29.92        | 76.74                  | 63.09           |
| Do .....                                                                      | 2         | 69.61       | 44.11   | 40.88    | 80.14   | 44.63        | 82.88                  | 75.49           |
| Prickly pear, calculated from feed of prickly pear and cotton-seed meal ..... | 1         | 64.50       | 39.01   | -41.89   | 68.08   | 39.03        | 81.67                  | 72.19           |
| Do .....                                                                      | 2         | 65.29       | 39.96   | -38.31   | 88.11   | 39.48        | 82.23                  | 72.74           |
| Average .....                                                                 |           | 64.90       | 39.49   | -40.60   | 88.10   | 39.25        | 81.95                  | 72.47           |
| Prickly pear and alfalfa ..                                                   | 1a        | 56.84       | 21.46   | 40.84    | 51.41   | 35.80        | 75.09                  | 61.57           |
| Do .....                                                                      | 2         | 65.87       | 43.22   | 56.05    | 62.89   | 42.51        | 80.36                  | 70.34           |
| Average .....                                                                 |           | 61.36       | 32.34   | 48.75    | 57.15   | 39.16        | 77.73                  | 65.96           |
| Prickly pear and cotton-seed meal .....                                       | 1         | 67.46       | 39.03   | 74.53    | 91.56   | 44.28        | 77.97                  | 73.60           |
| Do .....                                                                      | 2         | 68.17       | 39.05   | 72.33    | 91.41   | 44.05        | 77.97                  | 74.15           |
| Average .....                                                                 |           | 67.82       | 39.04   | 73.43    | 91.49   | 44.17        | 77.97                  | 73.88           |
| Alfalfa alone. ....                                                           | 1         | 56.43       | 43.83   | 65.99    | 44.91   | 42.49        | 68.15                  | 57.87           |
| Do .....                                                                      | 2         | 55.33       | 34.75   | 65.12    | 30.97   | 32.20        | 71.52                  | 57.63           |
| Average .....                                                                 |           | 55.88       | 39.29   | 65.56    | 37.94   | 40.35        | 69.84                  | 57.75           |
| Alfalfa when fed with prickly pear. ....                                      | 1a        | 39.35       | 38.90   | 29.76    | 26.54   | 26.65        | 57.04                  | 42.24           |
| Do .....                                                                      | 2         | 68.41       | 80.59   | 60.65    | 52.28   | 37.29        | 78.35                  | 64.38           |
| Average .....                                                                 |           | 53.88       | 59.75   | 45.21    | 39.41   | 31.97        | 67.85                  | 53.31           |

a The digestion coefficients obtained from steer No. 1 that was fed a ration of prickly pear and alfalfa are all evidently too low and should not be used in the preparation of rations from either prickly pear, alfalfa, or the mixed feed.

TABLE 14.—*Summary of all digestion coefficients obtained in these Experiments, together with some coefficients of alfalfa and cotton-seed meal as determined elsewhere.—Continued.*

| Feed.                                                             | Steer No. | Dry matter. | Ash.    | Protein. | Fat.    | Crude fiber. | Nitrogen-free extract. | Organic matter. |
|-------------------------------------------------------------------|-----------|-------------|---------|----------|---------|--------------|------------------------|-----------------|
|                                                                   |           | Per ct.     | Per ct. | Per ct.  | Per ct. | Per ct.      | Per ct.                | Per ct.         |
| Alfalfa, Colorado Experiment Station.....                         |           | 63.95       | 57.67   | 72.54    | 29.86   | 49.93        | 72.89                  | .....           |
| Alfalfa: <i>b</i>                                                 |           |             |         |          |         |              |                        |                 |
| Maximum.....                                                      |           | 60.20       | 40.90   | 77.00    | 54.00   | 49.03        | 71.80                  | .....           |
| Minimum.....                                                      |           | 57.00       | 38.00   | 68.80    | 48.40   | 43.30        | 64.00                  | .....           |
| Average.....                                                      |           | 58.90       | 39.50   | 72.00    | 51.00   | 45.00        | 69.20                  | .....           |
| Alfalfa, Minnesota Experiment Station.....                        |           | 65.84       | 51.48   | 75.38    | 55.88   | 57.57        | 71.86                  | .....           |
| Alfalfa, Kansas Experiment Station:                               |           |             |         |          |         |              |                        |                 |
| First cut.....                                                    |           | 59.40       | 63.49   | 78.52    | 60.00   | 46.10        | 75.31                  | .....           |
| Second cut.....                                                   |           | 58.25       | 56.41   | 75.14    | 30.39   | 40.44        | 71.99                  | .....           |
| Third cut.....                                                    |           | 60.03       | 60.90   | 76.70    | 51.65   | 50.63        | 75.24                  | .....           |
| Alfalfa, Utah Experiment Station.....                             |           | 60.16       | 40.85   | 70.30    | 50.57   | 45.67        | 71.80                  | .....           |
| Cotton-seed meal: <i>b</i>                                        |           |             |         |          |         |              |                        |                 |
| Maximum.....                                                      |           | 83.90       | 38.00   | 96.10    | 103.20  | 100.00       | 71.00                  | 87.00           |
| Minimum.....                                                      |           | 65.00       | 3.00    | 83.50    | 87.30   | 19.50        | 43.40                  | 69.10           |
| Average.....                                                      |           | 73.70       | 23.70   | 88.40    | 93.30   | 55.50        | 60.60                  | 76.10           |
| Cotton-seed meal from feed of cotton-seed meal with prickly pear. | 1         | 72.84       | 47.42   | 77.51    | 102.7   | 37.04        | 64.83                  | 75.09           |
| Do.....                                                           | 2         | 76.88       | 67.22   | 69.89    | 104.6   | 34.06        | 72.71                  | 77.28           |
| Average.....                                                      |           | 74.86       | 57.32   | 73.70    | 103.7   | 35.55        | 68.77                  | 76.19           |

*b*Bulletin 77, Office of Experiment Stations, U. S. Dept. of Agriculture.

TABLE 15.—Daily rations fed during the five digestion periods, and a maintenance ration for each steer calculated from Wolff's feeding standard for oxen at rest in stalls.

## STEER NO. 1.

| Experiment No. | Feed.                                         | Digestible organic matter. |          |                |         |                  | Nutritive ratio. |
|----------------|-----------------------------------------------|----------------------------|----------|----------------|---------|------------------|------------------|
|                |                                               | Dry matter.                | Protein. | Carbohydrates. | Fat.    | Total nutrients. |                  |
|                |                                               | Pounds.                    | Pounds.  | Pounds.        | Pounds. | Pounds.          |                  |
| 1.....         | Prickly pear ( <i>Opuntia lindheimeri</i> ).. | 13.84                      | 0.42     | 7.44           | 0.13    | 8.00             | 1:18.23          |
| 2.....         | Prickly pear ( <i>O. laevis</i> ).....        | 6.64                       | .11      | 3.57           | .08     | 3.76             | 1:33.56          |
| 3.....         | Prickly pear and alfalfa.....                 | 12.99                      | .35      | 6.48           | .11     | 6.94             | 1:19.13          |
| 4.....         | Prickly pear and cotton-seed meal.            | 14.14                      | 1.68     | 6.13           | .62     | 8.43             | 1: 4.49          |
| 5.....         | Alfalfa.....                                  | 14.19                      | 1.31     | 5.98           | .11     | 7.40             | 1: 4.75          |
|                | Maintenanceration                             | 15.10                      | .60      | 6.90           | .13     | 7.66             | 1:12             |

## STEER NO. 2.

|        |                                               |       |      |      |      |       |         |
|--------|-----------------------------------------------|-------|------|------|------|-------|---------|
| 1..... | Prickly pear ( <i>Opuntia lindheimeri</i> ).. | 12.98 | 0.40 | 6.98 | 0.13 | 7.50  | 1:18.23 |
| 2..... | Prickly pear ( <i>O. laevis</i> ).....        | 9.36  | .16  | 5.02 | .11  | 5.29  | 1:33.04 |
| 3..... | Prickly pear and alfalfa.....                 | 16.44 | .56  | 8.93 | .17  | 9.66  | 1:16.65 |
| 4..... | Prickly pear and cotton-seed meal.            | 17.35 | 1.75 | 8.09 | .68  | 10.52 | 1: 5.52 |
| 5..... | Alfalfa.....                                  | 14.23 | 1.32 | 5.98 | .11  | 7.40  | 1: 4.74 |
|        | Maintenanceration                             | 16.70 | .67  | 7.65 | .14  | 8.43  | 1:12    |

TABLE 16. -- *Weight of feed eaten, feces and urine excreted, and water drunk during the five digestion periods.*

| Experiment No. | Steer No. | Feed.                                            | Weight of feed for five days. |         | Average weight of feed per day. |         | Weight of feces for five days. |         |
|----------------|-----------|--------------------------------------------------|-------------------------------|---------|---------------------------------|---------|--------------------------------|---------|
|                |           |                                                  | Grams.                        | Pounds. | Grams.                          | Pounds. | Grams.                         | Pounds. |
| 1a             | 1         | Prickly pear ( <i>Opuntia lindheimeri</i> )..... | 187,539                       | 413.63  | 46,884.75                       | 103.41  | 62,766                         | 138.43  |
|                | 2         | Prickly pear ( <i>O. lindheimeri</i> ).....      | 179,314                       | 395.48  | 44,828.5                        | 98.87   | 58,591                         | 129.23  |
| 2              | 1         | Prickly pear ( <i>O. laevis?</i> )...            | 121,322                       | 267.58  | 2,426.44                        | 53.52   | 20,293                         | 44.75   |
|                | 2         | Prickly pear ( <i>O. laevis?</i> )...            | 163,620                       | 360.89  | 32,726                          | 72.18   | 38,896                         | 85.79   |
| 3              | 1         | Prickly pear....                                 | 95.5                          | 210.81  | 19.116                          | 42.16   | .....                          | .....   |
|                |           | Alfalfa.....                                     | .....                         | 22.51   | 2.041                           | 4.50    | .....                          | .....   |
|                |           | Total.....                                       | 105,785                       | 233.32  | 21.157                          | 46.66   | 63,555                         | 139.73  |
|                | 2         | Prickly pear....                                 | 129,627                       | 285.89  | 25,925.4                        | 57.18   | .....                          | .....   |
|                |           | Alfalfa.....                                     | 10,702                        | 23.60   | 2,140.4                         | 4.72    | .....                          | .....   |
| 4              | 2         | Total.....                                       | 140,329                       | 309.49  | 28,065.8                        | 61.90   | 73,485                         | 162.07  |
|                |           | Prickly pear..                                   | 84,498                        | 186.36  | 16,899.8                        | 37.27   | .....                          | .....   |
|                |           | Cotton-seed meal.....                            | 10,845                        | 23.92   | 2,169.0                         | 4.78    | .....                          | .....   |
|                | 1         | Total.....                                       | 95,343                        | 210.28  | 19,068.8                        | 42.05   | 54,605                         | 120.43  |
|                |           | Prickly pear..                                   | 106,645                       | 235.21  | 21,329.0                        | 47.04   | .....                          | .....   |
| 2              | 2         | Cotton-seed meal.....                            | 11,318                        | 24.96   | 2,263.6                         | 4.99    | .....                          | .....   |
|                |           | Total.....                                       | 117,963                       | 260.17  | 23,592.6                        | 52.03   | 75,155                         | 165.76  |
| 1              | 1         | Alfalfa.....                                     | 339,922.4                     | 749.72  | 67,984.5                        | 149.94  | 62,800                         | 138.51  |
|                | 2         | Alfalfa.....                                     | 340,050                       | 750.0   | 68,010.0                        | 150.0   | 81,190                         | 179.07  |

a This experiment lasted for a period of four days only.

TABLE 16.—*Weight of feed eaten, feces and urine excreted, and water drunk during the five digestion periods.*—Continued.

| Experiment No. | Steer No. | Feed.                                                | Average weight of feces per day. |         | Weight of urine for five days. |         | Average weight of urine per day. |         |
|----------------|-----------|------------------------------------------------------|----------------------------------|---------|--------------------------------|---------|----------------------------------|---------|
|                |           |                                                      | Grams.                           | Pounds. | Grams.                         | Pounds. | Grams.                           | Pounds. |
| 1a             | 1         | Prickly pear<br>( <i>Opuntia lindheimeri</i> ) ..... | 15,691.5                         | 34.61   | 51,981                         | 114.65  | 12,995.2                         | 28.66   |
|                | 2         | Prickly pear<br>( <i>O. lindheimeri</i> ) .....      | 14,647.75                        | 32.31   | 38,915                         | 85.83   | 9,728.75                         | 21.46   |
| 2              | 1         | Prickly pear<br>( <i>O. laevis</i> f)...             | 4,058.6                          | 8.95    | 26,874                         | 59.27   | 5,374.8                          | 11.85   |
|                | 2         | Prickly pear<br>( <i>O. laevis</i> f)...             | 7,779.2                          | 17.16   | 50,848                         | 112.15  | 10,169.6                         | 22.43   |
|                | 1         | Prickly pear.....                                    |                                  |         |                                |         |                                  |         |
|                |           | Alfalfa .....                                        |                                  |         |                                |         |                                  |         |
|                |           | Total.....                                           | 12,671                           | 27.94   | 31,700                         | 69.92   | 6,340                            | 13.98   |
|                | 2         | Prickly pear.....                                    |                                  |         |                                |         |                                  |         |
|                |           | Alfalfa .....                                        |                                  |         |                                |         |                                  |         |
|                |           | Total.....                                           | 14,697                           | 32.41   | 42,322                         | 93.12   | 8,444.4                          | 18.62   |
| 4              | 1         | Prickly pear...<br>Cotton-seed meal.....             |                                  |         |                                |         |                                  |         |
|                |           | Total ..                                             | 10,921                           | 24.09   | 26,975                         | 63.91   | 5,795                            | 12.78   |
|                | 2         | Prickly pear...<br>Cotton-seed meal.....             |                                  |         |                                |         |                                  |         |
|                |           | Total ...                                            | 15,031                           | 33.15   | 37,525                         | 82.76   | 7,505                            | 16.55   |
| 5              | 1         | Alfalfa .....                                        | 12,560                           | 27.70   | 44,785                         | 98.77   | 8,959                            | 19.75   |
|                | 2         | Alfalfa .....                                        | 16,238                           | 35.81   | 43,910                         | 96.84   | 8,782                            | 19.37   |

a This experiment lasted for a period of four days only.

TABLE 16.—*Weight of feed eaten, feces and urine excreted, and water drunk during the five digestion periods.*—Continued.

| Experiment No. | Steer No. | Feed.                                            | Weight of water drunk for five days. |         | Average weight of water per day. |         |
|----------------|-----------|--------------------------------------------------|--------------------------------------|---------|----------------------------------|---------|
|                |           |                                                  | Grams.                               | Pounds. | Grams.                           | Pounds. |
| 1a             | 1         | Prickly pear ( <i>Opuntia lindheimeri</i> )..... | None.                                | None.   | None.                            | None.   |
|                | 2         | Prickly pear ( <i>O. lindheimeri</i> ).....      | None.                                | None.   | None.                            | None.   |
| 2              | 1         | Prickly pear ( <i>O. laevis</i> ?).....          | 17,225                               | 37.99   | 3,445                            | 7.60    |
|                | 2         | Prickly pear ( <i>O. laevis</i> ?).....          | 12,275                               | 27.07   | 2,455                            | 5.41    |
| 3              |           | Prickly pear.....                                |                                      |         |                                  |         |
|                | 1         | Alfalfa.....                                     |                                      |         |                                  |         |
|                |           | Total.....                                       | 47,263                               | 91.01   | 9,252.6                          | 18.2    |
|                |           | Prickly pear.....                                |                                      |         |                                  |         |
|                | 2         | Alfalfa.....                                     |                                      |         |                                  |         |
| 4              |           | Total.....                                       | 43,240                               | 95.37   | 8,648                            | 19.07   |
|                |           | Prickly pear.....                                |                                      |         |                                  |         |
|                | 1         | Cotton seed meal.....                            |                                      |         |                                  |         |
|                |           | Total.....                                       | 66,700                               | 147.11  | 13,340                           | 29.42   |
|                |           | Prickly pear.....                                |                                      |         |                                  |         |
| 5              |           | Cotton-seed meal.....                            |                                      |         |                                  |         |
|                | 2         | Total.....                                       | 83,475                               | 184.11  | 16,695                           | 36.82   |
|                |           | Alfalfa.....                                     |                                      |         |                                  |         |
|                | 1         | Alfalfa.....                                     | 106,480                              | 234.86  | 21,296                           | 46.97   |
|                | 2         | Alfalfa.....                                     | 110,980                              | 244.77  | 22,196                           | 48.95   |

<sup>a</sup> This experiment lasted for a period of four days only.

#### INCOME AND OUTGO OF NITROGEN.

In table 17 is given the income and outgo of nitrogen for both steers during the five digestion periods. The gain or loss of nitrogen is the difference between the amount taken into the animal as food and the sum of that which is excreted in the feces and urine.

It is interesting to note that in the first digestion period, when the steers were fed prickly pear (*Opuntia lindheimeri*) alone which had a nutritive ratio of 1 to 18.23, they each gained nearly 1 pound of proteids in the four days. Steer No. 1, for example, ate 1,322.8

grams (2.9 pounds) of protein and gained 453.1 grams (1 pound) or 34.26 per cent.

Prickly pear alone was the ration also for the second period, but in this experiment a different species was used, as well as different steers, and the latter were fat from a previous grain ration and not accustomed to eating prickly pear. Analysis shows that the feed from this species of prickly pear has about 1 per cent less protein than the species fed in the first period. The steers ate only about half the ration eaten by the steers for the first period and digested about 18 per cent less of the protein. As a consequence the nutritive ratio in this feed was 1 to 33 for both steers, and each lost over one-half pound of protein, or nearly 50 per cent of that eaten during their five-day digestion period. Steer No. 1, for example, consumed 99.2 grams and excreted 146.1 grams of nitrogen in the five days, making a loss of 293.1 grams (0.65 pound) of protein, or 47.28 per cent. In the third digestion period steer No. 1 ate 42.16 pounds of prickly pear and 4.5 pounds of alfalfa daily, while steer No. 2 ate 57.18 pounds and 4.72 pounds of alfalfa. Something went wrong in this experiment with either steer No. 1 or our analyses, we can not say which, although fairly closely agreeing duplicate determinations were secured in all the analyses. Table 17 shows a low digestion coefficient by this steer for all the nutrients. This animal consumed 312.4 grams of nitrogen for the five days, and excreted 346.5 grams, making a loss of 213.1 grams of protein, or 10.9 per cent of the nitrogen consumed. There was excreted in the urine 51.76 per cent, while with steer No. 2, on practically the same ration, only 28.16 per cent of the nitrogen was in the urine.

The results obtained with steer No. 2 were more satisfactory throughout. He showed a normal digestion coefficient for all the nutrients, but it was hardly enough for the proteids to make a theoretical maintenance ration for him; yet we find a daily gain in Table 17 of 127.6 grams of this nutrient.

There was a quite uniform gain of nitrogen for both steers during the fourth digestion period in which prickly pear and cotton-seed meal composed the ration. The gain for steer No. 1 amounted to 30.46 per cent, and for steer No. 2, to 23.07 per cent.

Fifteen pounds of alfalfa per day was the ration for both steers during the fifth period. The digestion coefficient for the two was close enough to make a nutritive ratio for both of 1 to 4.75.

From Table 15 it may be seen that steer No. 1 digested or retained in his system 1.31 pounds, and No. 2, 1.32 pounds of protein during this period. According to Wolff's standard for oxen at rest in stalls these figures are 0.71 pound for steer No. 1 and 0.65 pound for steer No. 2 in excess of the amount required for maintenance; yet we find that during the five days steer No. 1 gained only 302.5 grams (0.66 pound) of protein, and steer No. 2 actually lost 222.5 grams (0.5 pound). Why there should be such a slight gain of protein for steer No. 1 and a loss for No. 2 when the proteids actually digested by both were far in excess of the estimated amount required we are at a loss to say. It may be explained, however, by the supposition that because of the narrow nutritive ratio of the feed neither steer had a maintenance ration of nonproteids, and to supply the necessary energy their bodies broke down the proteids and used the non-nitrogenous part of the molecule, excreting through the kidneys the nitrogenous portion produced from the cleavage. That such is the case would seem to be shown by the fact that steer No. 2, for example, in consuming 727.6 grams (1.6 pounds) of nitrogen excreted 504.9 grams (1.1 pounds) or 70.01 per cent in the urine.

TABLE 17.—Income and outgo of nitrogen during the five digestion periods.

| Experiment No. | Feed.                                                                          | Steer No. | Nitrogen in urine. | Nitrogen in feces. | Total nitrogen excreted. | Total nitrogen eaten. | Nitrogen (gain, +; loss, -). |
|----------------|--------------------------------------------------------------------------------|-----------|--------------------|--------------------|--------------------------|-----------------------|------------------------------|
|                |                                                                                |           | Grams.             | Grams.             | Grams.                   | Grams.                | Grams.                       |
| 1              | Prickly pear ( <i>Opuntia lindheimeri</i> ) . . . . .                          | 1         | 52.5               | 86.6               | 139.1                    | 211.6                 | + 72.5                       |
|                |                                                                                | 2         | 47.1               | 84.4               | 131.5                    | 198.4                 | + 66.9                       |
| 2              | Prickly pear ( <i>O. leavis</i> F.) . . . . .                                  | 1         | 85.0               | 60.1               | 145.1                    | 99.2                  | - 46.9                       |
|                |                                                                                | 2         | 121.5              | 81.7               | 203.2                    | 140.0                 | - 63.2                       |
| 3              | Prickly pear ( <i>O. engelmannii cycloides</i> ) and alfalfa . . . . .         | 1         | 181.7              | 184.8              | 366.5                    | 312.4                 | - 54.1                       |
|                |                                                                                | 2         | 100.9              | 155.3              | 256.2                    | 354.3                 | +102.1                       |
| 4              | Prickly pear ( <i>O. engelmannii cycloides</i> ) and cottonseed meal . . . . . | 1         | 359.3              | 207.7              | 567.0                    | 815.3                 | +248.3                       |
|                |                                                                                | 2         | 431.5              | 242.2              | 673.7                    | 875.7                 | +202.0                       |
| 5              | Alfalfa . . . . .                                                              | 1         | 430.0              | 246.5              | 676.5                    | 724.9                 | + 48.4                       |
|                |                                                                                | 2         | 509.4              | 233.8              | 743.2                    | 727.6                 | - 35.6                       |



TABLE 17.—Income and outgo of nitrogen during the five digestion periods—Continued.

| Experiment No. | Feed.                                                                       | Steer No. | Proteids            | Nitrogen            | Excreted           | Excreted           |
|----------------|-----------------------------------------------------------------------------|-----------|---------------------|---------------------|--------------------|--------------------|
|                |                                                                             |           | (gain, +; loss, -). | (gain, +; loss, -). | nitrogen in feces. | nitrogen in urine. |
|                |                                                                             |           | Grams.              | Per cent.           | Per cent.          | Per cent.          |
| 1              | Prickly pear ( <i>Opuntia lindheimeri</i> ).....                            | 1         | + 453.1             | +34.26              | 41.93              | 24.82              |
|                |                                                                             | 2         | + 418.1             | +33.72              | 42.54              | 23.74              |
| 2              | Prickly pear ( <i>O. laevis?</i> ).....                                     | 1         | - 293.1             | -47.28              | 60.58              | 86.69              |
|                |                                                                             | 2         | - 395.0             | -45.14              | 58.35              | 86.79              |
| 3              | Prickly pear ( <i>O. engelmannii cyclotides</i> ) and alfalfa.....          | 1         | - 213.1             | -10.92              | 59.15              | 51.76              |
|                |                                                                             | 2         | + 638.1             | +28.50              | 43.34              | 28.16              |
| 4              | Prickly pear ( <i>O. engelmannii cyclotides</i> ) and cotton-seed meal..... | 1         | + 1,551.9           | +30.46              | 25.47              | 54.09              |
|                |                                                                             | 2         | + 1,262.5           | +23.07              | .....              | 49.16              |
| 5              | Alfalfa.....                                                                | 1         | + 302.5             | + 6.68              | 34.00              | 59.32              |
|                |                                                                             | 2         | - 222.5             | - 4.89              | 34.88              | 70.01              |

## CONCLUSIONS.

(1) The average digestibility of the nutrients of prickly pear as determined in the first experiment where *Opuntia lindheimeri* was used were: Dry matter, 65.86 per cent; ash, 33.68 per cent; protein, 57.47 per cent; fat, 68.38 per cent; crude fiber, 41.32 per cent; nitrogen-free extract, 81.78 per cent.

In the second experiment where the variety *O. laevis?* was used the coefficients of digestion were: Dry matter, 63.96 per cent; ash, 25.81 per cent; protein, 40.87 per cent; fat, 69.02 per cent; crude fiber, 53.99 per cent; nitrogen-free extract, 78.95 per cent.

In general these results would perhaps show a somewhat low coefficient for protein, a decidedly low coefficient for ash, but a very high coefficient for the nitrogen-free extract. The total digestible nutrients are about equal to those of immature green corn fodder.

(2) Our experiments seem to show that when prickly pear is fed with cured fodders or grains the digestibility of both is increased. For this reason prickly pear has a greater food value than is shown by its analysis and digestion coefficients.

(3) The nutritive ratio, i. e., the ratio of proteids to carbohydrates, is very wide for this feed, and in feeding it to all classes of animals, for whatever purpose, much better results should be obtained when it is fed with some substance of a high protein content.

(4) While the digestibility of the ash was apparently small, as noted above, yet the large amount of ash contained in these plants caused more ash to be assimilated from a ration equivalent to 15 pounds of dry matter than is ordinarily assimilated from an equal ration of alfalfa, which has a higher coefficient of digestion for its ash.

(5) The steers seldom drank water when fed prickly pear alone. In fact, in feeding a ration of 100 pounds of this feed per day the animals obtained from the feed over 8 gallons of water, which is more than was usually drunk by them when fed cured fodders alone.

(6) While no digestion experiments were made with any of the cacti other than prickly pear, the digestion coefficients of the latter could probably be safely used for all other members of this family, since their composition and other characteristics are similar.

(7) It may be seen that both steers gained proteids during the first experiment, although both ate a smaller quantity of dry matter which contained less proteids than are required according to Wolff's standard ration for oxen of their weight at rest in stalls.

In the second experiment both animals lost proteids, but here steer No. 1 ate less than half of what was eaten by steer No. 1 in the first experiment, and steer No. 2 ate over 3 pounds less than steer No. 2 of experiment No. 1.

(8) Animals scour quite badly when fed prickly pear alone; besides, other feeds are needed to supply the proper amount of proteids; and for these reasons it is better not to feed it alone.

A ration for a 1,000-pound milch cow of 50 pounds of prickly pear, 10 pounds of wheat bran, and 10 pounds of alfalfa would furnish about the correct theoretical amount of nutrients, in which the ratio of proteids to carbohydrates would be 1 to 5.46.

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New Mexico College of Agriculture and Mechanic Arts

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AGRICULTURAL EXPERIMENT STATION

AGRICULTURAL COLLEGE, N. M.



Eleven Varieties.

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# SWEET POTATO CULTURE

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BY  
FABIÁN GARCÍA

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SANTA FE, N. M.:  
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# **New Mexico Agricultural Experiment Station**

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The Bulletins of this Station will be mailed free to citizens of New Mexico and to others, as far as the editions printed will allow, on application to the Director.

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## **SWEET POTATO CULTURE**

### **Introduction**

The sweet potato (*Ipomoea batatas*) belongs to the same family of plants that the morning glory does. The plant is a low trailing vine and very sensitive to frost. The tuberous roots which vary in size and color, according to the variety grown, are used as a table vegetable, or may be fed to stock. The sweet potato is probably a native of tropical America and thrives best in warm climates. While sweet potatoes are grown in favorable spots as far north as Michigan and Maine, they are not usually raised on a commercial scale north of New Jersey. Most of the sweet potatoes raised for commercial purposes are grown in the southern states and in California.

In New Mexico the sweet potato is well adapted to the lower and warmer valleys. In the Mesilla Valley it does excellently while in the northern and elevated mountainous portions of the Territory sweet potatoes are not generally grown. Since the sweet potato is well adapted to the lower and warmer sections of the Territory it is possible that this crop may take a place beside the more profitable crops whenever more intensive farming is done and an outside market is developed. It is a comparatively easy crop to grow and yields well.

For the past three years the New Mexico Experiment Station has conducted experiments along the more practical lines in order to get data which may be helpful to those who may wish to become sweet potato growers. The principal lines of experimentation have been the testing of varieties, the test of vitality of plants grown at home and those shipped in from outside states, keeping tests, cost of production, yield, and effect of pruning vines.

### Soil

While the sweet potato does better in a sandy loam than in an adobe soil, the best results may be had from a loam which is rich and conserves moisture well. Potatoes grown in good rich loam yield heavily and are, as a rule, of good marketable size, smooth surface and clean in most respects; while potatoes grown in our heavy adobe soils are irregular in shape, have a very rough surface and are not uniform in size. On the other hand very sandy soils produce low yields. Sometimes in adobe soils there are some very large potatoes to be found and again there are a great many small and ill-shaped tubers. The heavy adobe soil does not permit the tuber to grow uniform and smooth. This is particularly true when the soil is allowed to become too dry.

### Preparation of Soil

As a rule the land on which potatoes are to be grown does not require any special preparation. It ought, however, to be plowed in the fall and if possible, irrigated during the winter before the final ridging is done. Just before the plants are to be transplanted the land should be thrown up in ridges about  $3\frac{1}{2}$  to 4 feet apart. These ridges are plowed up by means of a two horse plow. As a rule they vary from about eight to twelve inches high. Sometimes, though it is not the rule, the ridges are irrigated before the plants are transplanted. This is done in order to settle the ridges and to moisten the soil.

### Propagation

Sweet potatoes are propagated by means of what are called "slips." A slip is a sprout which develops from the invisible buds or eyes on the surface of the sweet potato. The tuber is capable of producing a large number of slips. While the common method of propagating sweet potatoes is by means of these slips, they can also be propagated from cuttings. The cuttings are usually taken from the slips which have been planted in the field and which have made a growth of four to



ten inches. The cuttings are taken off and either rooted in a favorable place or may be transplanted at once into the field.

### **Propagation of Slips**

In order to get the sweet potato slips it is necessary to bed out the tubers. The common method of bedding out the sweet potatoes is in a cold frame or hot bed. It has been found at this Station that on the whole better results were obtained from the cold frame than from the hot bed. See *Fig 1*. In



Figure 1. Sweet potato slips in a cold frame ready to be pulled.

the bottom of the cold frame a layer of sweet potatoes is placed and covered over with sand or very sandy soil to a depth of 2 or 3 inches. This is then irrigated well and a glazed cold frame sash is placed over the frame. Occasional sprinkling will be necessary to keep the soil moist during the time the sweet potatoes are sprouting. At the Experiment Station it has been the practice to bed the sweet potatoes in the cold frame about the first of March. In our climate and under the conditions

in which the potatoes are grown they sprout very quickly so that the first crop of slips can be transplanted by the first week in April. Immediately after the first crop of slips is taken off, the sweet potato bed must be sprinkled over thoroughly and if any of the tubers have become exposed they must be covered over. In ten or fifteen days another crop of slips is ready for transplanting. After the second crop of slips is taken off, the sweet potato bed must be treated as before. From three to five crops of slips can be taken off if care is taken of the bed. At the Station it has taken from 85 to 100 pounds of the average size Bermuda sweet potatoes for a bed three by six feet.

### Transplanting

As has already been stated, the ridges for the sweet potatoes should be made shortly before the plants are transplanted. If it is desired, though this is not necessary, one may irrigate the ridges before transplanting. This practice, however is not general. Most growers transplant the plants in the dry earth and irrigate immediately after transplanting. With the latter method one should be careful not to allow the plants which have been transplanted to remain too long before they are irrigated. Another plan is to have the men transplant a little ahead of a small stream of water. *Irrigate the plants as soon as possible after they are transplanted.* About a week after the transplanting is done another irrigation should be given. If the ridges are irrigated before the plants are transplanted it should be done a few days ahead not to delay the operation. The irrigation of the plants in rows which have been previously irrigated must be done as for plants which are planted in the dry ridges. As far as the matter of irrigation is concerned there is no difference in the two methods. Some potato growers turn in a stream of water and transplant in the water while it is running. This method is somewhat tedious and slow. Some growers transplant on both sides of the ridges, others on top of the ridge, but the best method is to transplant on one side only. The size of the

slips to transplant varies from about four to eight inches in length.

The distance at which to transplant varies somewhat. At this station it has been the practice to make the ridges from  $3\frac{1}{2}$  to 4 feet apart and transplant in the rows from 15 to 18 inches apart. These distances have given good results. Oftentimes the sweet potatoes, and especially the Bermuda type, grow too large. It is believed that in such cases the size may be reduced, other things remaining favorable, by reducing the distance of the plants in the row.

### Cultivation

The cultivation of the sweet potato in this section is comparatively easy. From the time the sweet potato is transplanted it does not get any cultivation until the vine has made a growth of probably 10 to 12 inches. The first cultivation is given by means of a small plow and simply consists in plowing the dirt to the plants. The dirt plowed to the plants comes off the side of the adjoining ridge which has no plants. One or two of such cultivations are necessary during the year. After each plowing the work is completed by further drawing the loose dirt close up to the plants with a hoe. While this work is being done the weeds along the row can be hced out. By this method of cultivation the row of plants is finally shifted to the middle of the ridge. The cost of cultivation for the year depends somewhat on the soil and upon the amount of weeds which the soil may produce. Some soils are very weedy and this makes extra hoeing necessary. Under ordinary conditions two or three hoeings are enough for the year. The average cost of cultivating and hoeing for three years, at the station, was \$5.60 per acre.

### Irrigation

The sweet potato is one of the most drought resistant plants which we have in southern New Mexico. It will produce a crop with less water than any other vegetable. The fact that the

sweet potato is quite droughtresistant does not mean that the grower should not use as much water as is necessary to produce a good crop. At this station from six to ten irrigations have produced good yields. It has also been observed that if the sweet potatoes are kept well irrigated and the surface soil moist a larger crop is produced and the tubers are nearer the surface of the ground than when the surface soil is allowed to dry out too much. If the surface soil dries out too much the roots of the sweet potatoes tend to follow the moisture and go down deep into the soil. In such cases there is a development of the root seemingly at the expense of the crop, and the tubers are down quite deep in the soil besides. It is believed that if more frequent but lighter irrigations were given instead of heavy irrigations at long intervals better results could be obtained. Aside from a larger yield the sweet potatoes would form nearer the surface and it would be much easier to dig them out. When the sweet potatoes are near the surface they can be plowed out very easily without bruising them very much. If the tubers go down deep in the soil it is quite difficult and expensive to plow them out without bruising them.

### Harvesting

As a rule in this section sweet potatoes are allowed to remain in the field until the vines have been killed by the first frosts. To a certain extent the idea prevails among many farmers that sweet potatoes should be dug before the vines are killed by frost. It is claimed that the frost "runs down the vine into the tuber." As to whether this is a fact or not, we have no authentic data. All that can be said now is that practically all the sweet potatoes stored away are dug after the vines have been killed by the frost.

If the potatoes have made a vigorous growth it is necessary to remove the vines before the tubers are plowed out. This takes some time and the operation is more or less expensive. If the potatoes do not make a vigorous vine growth and are allowed to remain in the field two or three weeks after the

vines have been killed by frost they may be plowed out without removing the vines. If the vines are to be removed there are two methods of doing the work. One of these is by cutting the vines off at the crown of the plants with a hoe and dragging the vines to one side. *See Fig. 2.* This is very tedious work. The other is by running a plow down the row and pulling the vines off. This is much easier and considerably cheaper than the first method. Both of these plans have been tried at the station.



Figure 2. Cutting the vines off in the fall. This is a tedious method.

As soon as the vines are removed the potatoes may be either spaded out or plowed out. The spading out method is too expensive and can only be recommended for small home areas where a plow cannot be used. If the potatoes have been properly irrigated throughout the season and if the soil is quite loamy and rich the work of plowing them out will not be very hard. On the other hand if the soil is hard, heavy, and dry it will increase the work of plowing and also increase the number of bruised potatoes. At the station a number of tools have been experimented with for plowing out the sweet potatoes. A regular Irish potato digger has been used. A

lister has also been tried but none of these has given the satisfaction that the regular turning plow has given. The plow used at the station is a 16-inch plow pulled by a team of horses weighing about 1200 pounds each. In cases where the soil is hard and dry and the potatoes have grown down quite a depth it is advisable to put three horses to the plow. *See Fig. 3.*



Figure 3. Plowing out sweet potatoes with a three horse plow.

In digging the sweet potatoes it is necessary to have enough men following the plow so that the plowman will not lose any time in waiting for the sweet potatoes to be taken out of his way. It takes two furrows to plow out a whole row of sweet potatoes. The first one is plowed pretty close to the row and the second one turns out the row of tubers and leaves them practically all exposed. Then the men pick them out and put them aside out of the way of the team. In this climate the sweet potatoes are allowed to be out about five or six hours, but are covered at night or brought in. It is a good idea to allow them to sun at least five hours. In gathering the sweet potatoes the men must be careful in handling them.

Great care must be taken that the tubers are not bruised. The less they are bruised the less loss there will be from decaying.

### **Hauling the Sweet Potatoes**

If the sweet potatoes are hauled in sacks from the field to the storage building they are usually bruised considerably more than when hauled in boxes or baskets or even in the wagon bed. Whenever possible use boxes instead of sacks. The less sweet potatoes are handled the better it is for them.

### **Keeping Sweet Potatoes**

One of the most important things in sweet potato culture is the keeping of them. If the sweet potatoes are kept until February and March they will bring about twice as much as they do in October and November, when they are harvested. The uncertainty of being able to keep the sweet potatoes during the winter reduces the area planted. While sweet potatoes are uncertain in their keeping qualities they can be preserved quite satisfactorily when close attention is given to the subject. Those who are provided with suitable quarters for storage purposes and give attention to the details of digging and curing the tubers are well paid for their extra work. Some of the more important points to be considered in the keeping of sweet potatoes are (1) a suitable storage building, (2) great care in preventing the bruising of tubers, and (3) in curing the potatoes before they are put away. The sweet potato has, as a rule, a thin skin and is easily bruised. Bruised potatoes are more susceptible to decay. Therefore they should not be bruised and should be well cured before they are placed in the storage room. When the potatoes cannot be subjected to artificial heat to dry they should be thoroughly dried in the sun. The temperature at which sweet potatoes seem to keep the best is between 50 and 65 degrees F. In the large commercial sweet potato sections the crop is stored in dry, warm cellars or houses especially built for the purpose.\* In some

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\* Farmer's Bulletin No. 129, U. S. D. A.

localities the common method of storage is to place the sweet potatoes in a cone-shaped pile containing from 1,000 to 2,000 pounds. The pile is then covered with a layer of dry fine hay or straw, followed by a layer of corn stalks, and on top of all this two or three inches of sand or dirt is placed. In the Mesilla Valley the best results in keeping sweet potatoes have been obtained by stratifying the tubers in dry sand in a dry and thick walled adobe room.

At the station a test of different methods of keeping sweet potatoes was carried on during the winter of 1907-08. Three methods were used. One consisted in carefully placing the sweet potatoes in a pile shaped something like an oblong pyramid three feet high and four by ten feet at the base. This was covered over during the winter by means of a sheet



Fig. 4. A fairly satisfactory method of keeping sweet potatoes.

iron covered frame properly built for the purpose. *See Fig. 4.* One or two inches of earth were placed over the frame. The frames were left in the field all winter. The results



from this method of keeping the sweet potatoes were only fairly satisfactory. In the spring when the frames were taken off and the potatoes examined it was found that the potatoes on the north and east sides of the frame had decayed considerably, while those on the south and west sides of the frame were perfectly sound. Another method tried was by stratifying the tubers in sand. This gave very satisfactory results. The potatoes were kept in a cellar made specially for the experiment. The third method was simply placing the potatoes in a pile four feet high and about four feet square. The potatoes in this pile decayed considerably and it became necessary during the winter to sort them over twice.

In 1908 the keeping test was repeated. Most of the potatoes were put away in the cellar and some were covered over by the frames outside. Three bins were made in the cellar in which the experimental potatoes were kept. The three bins were floored and were as follows: Bin No. 1, 12x4x3 feet, bin No. 2, 2½x3x4 feet, bin No. 3, 4x3x4 feet. On November 5th and 6th, 1908, 5,417 pounds of good sound potatoes were placed in bin No. 1. On November 7th and 8th bins Nos. 2 and 3 were filled with 1350 and 1500 pounds respectively. The potatoes were first placed in all three bins; then in bins Nos. 1 and 3 sand was put in. Instead of stratifying the tubers in the sand as was done the previous year the sand was put on top of the potatoes and this sifted through to the bottom, filling up all of the openings between the potatoes. On November 23rd, 1908, 86 pounds of decaying tubers were taken out of bin No. 2. On account of the tubers not having been dried out sufficiently before they were put away they "sweated" enough for the sand to get quite moist. The moisture in the sand and the heat in the cellar started the sprouts on some of the potatoes. During the last week in December, 1908, the potatoes in all the bins were taken out and the sprouts were rubbed off. The decaying potatoes found were weighed and thrown away and the sand was taken out and dried. After all this work had

been done the potatoes were again placed in the bins and the dry sand put in bins Nos. 1 and 3. Up to this time bin No. 2 had lost more by decaying, according to the amount of potatoes it contained, than either of the other two bins. The weight of decayed potatoes in bins Nos. 1, 2, and 3 was 248, 122, and 83 pounds respectively.

### Growing Tests

The sweet potato experiment started in the spring of 1906 to ascertain the cost of production and yield per acre has been continued for three years. The land on which sweet potatoes grew in 1906 was a good rich loam and exceptionally free from weeds. A one-half acre plat 390 feet long by 55 feet wide was plowed and disked during the latter part of March. The ridges were laid off approximately  $3\frac{1}{2}$  feet apart making 15 rows to the plat. The plants were set 15 inches apart in the row, thus taking about 4,680 plants for the plat. Two hundred pounds of the White Bermuda seed potatoes were bedded in a cold frame February 28, 1906, and the plants from these tubers were ready to be set out as early as the 4th of April.

The following is a summary of the results obtained on this plat:

|                                                                                   |          |
|-----------------------------------------------------------------------------------|----------|
| Feb. 28, bedded 200 pounds of sweet potatoes bought at 5c per pound .....         | \$ 10.00 |
| Plowing plat with a 2-horse plow $2\frac{1}{4}$ hours @ 30c per hour .....        | .82      |
| Disking plat twice with acme 50 min. at 30c per hour. ....                        | .41      |
| April 10, ridging plat 3 hours 10 minutes @ 30c per hour .....                    | .95      |
| April 10-16, setting out plants and irrigating same 28 hours @ 10c per hour ..... | 2.80     |
| Subsequent irrigations (April 24, May 9, June 19, July 9, August 8 and 27) .....  | 2.50     |
| Cultivations and drawing dirt to vines (June 5 to 8 and July 5 to 7) .....        | 3.30     |
| October 24, removing vines 31-1-10 hours @ 10c per hour .....                     | 3.31     |

|                                                                                      |       |
|--------------------------------------------------------------------------------------|-------|
| Plowing out tubers with a three horse plow and two men, 3 hours @ 50c per hour ..... | 1.50  |
| Gathering, cleaning, and sacking tubers 42.82 hours @ 10c per hour .....             | 4.28  |
| Cost of 108 sacks for sacking tubers @ 10c each...                                   | 10.80 |

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|                                                                                                         |       |
|---------------------------------------------------------------------------------------------------------|-------|
| Total actual cost, not including the hauling of crop and the growing of the slips in the cold frame.... | 40.67 |
| Estimated cost of growing the slips .....                                                               | 5.00  |
| Estimated cost of hauling and storing the sweet potatoes .....                                          | 30.00 |

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|                                                   |          |
|---------------------------------------------------|----------|
| Total estimated cost per $\frac{1}{4}$ acre ..... | \$ 75.67 |
| Total estimated cost per acre .....               | 151.34   |

A few hundred pounds of sweet potatoes were dug during September and the earlier part of October, but most of them were harvested from October 23rd to 25th.

The  $\frac{1}{4}$  acre plat produced 10,809 pounds of sweet potatoes, which were sold as follows:

|                                     |          |
|-------------------------------------|----------|
| 1,488 pounds @ \$1.28 per cwt ..... | \$ 27.53 |
| 2,004 pounds @ \$1.65 per cwt ..... | 33.06    |
| 7,317 pounds @ \$1.35 per cwt ..... | 98.77    |

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|                                                                                 |          |
|---------------------------------------------------------------------------------|----------|
| Gross receipts from the $\frac{1}{4}$ acre .....                                | \$159.36 |
| The estimated gross receipts per acre according to these figures would be ..... | 318.72   |
| Estimated cost of production per acre .....                                     | 151.34   |

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|                                       |          |
|---------------------------------------|----------|
| Estimated net receipts per acre ..... | \$167.38 |
|---------------------------------------|----------|

The good returns from this plat are dependent, to a certain degree on the good rich and clean soil, a good season, and a good market. During 1906 the mining camps, to which most of these potatoes were sold, afforded a good market.

This sweet potato experiment was continued in 1907, and on March 2nd, 500 pounds of the White and Red Bermuda varieties were bedded in a cold frame. These seed potatoes were bought at five cents per pound from a Mexican farmer

in Mesilla. The potatoes had been kept all winter in an adobe room and they were in excellent condition. On April 2nd and 3rd a one acre plat 461 feet long by 94.5 feet wide was furrowed and the furrows smoothed over, taking  $8\frac{1}{2}$  hours (man and team) at 30c per hour or \$2.50. There were 26 ridges to the plat about  $3\frac{1}{2}$  feet apart. The soil in this plat was not quite as uniform as the one used in 1906. It was a loam, being quite sandy at the east quarter of the plat and having a small strip of alkali soil near the center of the field; this proved to be more or less injurious to the plants. On April 4th the plat was irrigated, before planting, with pumped water. The first irrigation over newly plowed ground took three hours pumping, for which the total cost was two dollars. This irrigation of the ridges before planting was not absolutely necessary and is not a common practice, though occasionally it is done. On April 8th and 9th the sweet potato plants were set out and irrigated at a cost of \$5.70. The 500 pounds of tubers bedded in the cold frame produced enough slips from the first crop to plant one acre. By April 20th, when the second irrigation was given with ditch water, the plants had practically all started and were making a nice growth. The actual time required for this second irrigation was one hour. On account of the new ditch breaking so much and also having to watch the headgate the irrigation cost 60 cents or six times as much as ordinarily. During the night of April 21st every plant was killed by a severe freeze.\* On the 22nd of April all of the frozen plants were cut back to the surface of the ground to see if they would sprout again. On May 3rd the plat was irrigated with ditch water at a cost of 30 cents. An examination made the 12th of May showed that about one third of the frozen plants were sprouting somewhat slowly and unevenly. On May 13th a very heavy wind blew from the southeast, damaging considerably a large number of the plants which had started to sprout. After this wind it was found necessary to irrigate, which was done on the 15th of May at a cost of 30 cents.

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\* Such late and severe freezes as this one are not common.

About two thirds of the plants were replanted May 21st and 22nd. It cost \$2.75 to reset and irrigate the plat. During the last week in May the wind again considerably damaged a number of the plants in the sandy part of the plat. On June 3rd the plat was irrigated with ditch water at a cost of 30c. The plants which had been injured by the heavy winds the last of May were replanted on June 5th, costing \$1.50. On June 26th the plat was irrigated at a cost of 30 cents. The first cultivation was given June 29th and 30th at a cost of \$1.60. On account of the very unfavorable spring, the crop was started considerably later than in 1906. On July 10th the plat was cultivated and hoed, costing \$1.25. On the 11th of July an irrigation was given with well water at a total cost of \$1.32. The ground had been loosened by plowing on June 29th and July 10th, and no doubt for this reason it took longer to irrigate the plat than it usually did. On July 22nd the plat was irrigated with ditch water at a cost of 30 cents, while on August 15th and September 11th the plat was irrigated with well water. These last two irrigations cost \$2.65. The season of 1907 was quite dry, and frequently it was a difficult matter to get water when needed from the ditch and consequently the pump had to be used a number of times. This increased the cost of production quite a little.

The vines made a good growth during the summer. The larger the vines the more difficult and expensive it is to remove them. On November 8th and 9th men were set to removing the vines, taking them 62 hours or a total cost of \$6.20. In this case the vines were first cut off at the surface of the ground, rolled into small piles, and then thrown to the outside of the plat. Had the vines been removed by means of the plow the operation would have been considerably cheaper. On November 15th and 16th the sweet potatoes were dug. The ground had become so hard and dry that it was necessary to put three horses to the plow. To avoid bruising a large number of potatoes two men were used, one driving the team and the other handling the plow. The time required to plow out the sweet potatoes was seven hours

or a cost of \$3.50, while it took 76 hours to clean, gather, and pile the tubers, costing \$7.60. Just before the sweet potatoes were hauled in, it started to rain. This made it necessary to leave the tubers in the field in small piles a day longer. The one acre plat produced 14602 pounds. The sandy part of the plat as well as the alkali strip produced a large number of small tubers which no doubt reduced the yield. On the whole the season of 1907 was not as favorable as that of 1906.

#### Summary of this Test

|                                                                                                                                                                         |          |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|
| 500 pounds of seed potatoes @ 5c. per pound .....                                                                                                                       | \$ 25.00 |
| Preparing and ridging the plat.....                                                                                                                                     | 2.50     |
| Irrigation .....                                                                                                                                                        | 8.07     |
| Transplanting and resetting.....                                                                                                                                        | 10.15    |
| Cultivation .....                                                                                                                                                       | 4.66     |
| Removing the vines .....                                                                                                                                                | 6.20     |
| Plowing out the sweet potatoes .....                                                                                                                                    | 3.50     |
| Cleaning and gathering the sweet potatoes .....                                                                                                                         | 7.60     |
| <hr/>                                                                                                                                                                   |          |
| Total cost of production not including the hauling of<br>the crop, growing of the slips, the cost of the sacks,<br>and the care of the sweet potatoes during the winter | 67.68    |
| Estimated cost of growing the slips.....                                                                                                                                | 5.00     |
| Estimated cost of hauling the crop from the field....                                                                                                                   | 10.00    |
| Estimated cost of 146 sacks. ....                                                                                                                                       | 14.60    |
| Estimated cost of care of sweet potatoes during the<br>winter, hauling sand, sorting, etc.....                                                                          | 25.00    |
| <hr/>                                                                                                                                                                   |          |
| Total estimated cost per acre.....                                                                                                                                      | \$122.28 |

The potatoes were stored and shipped out during the winter, though the market on the whole was poorer and the prices lower than for the previous season. On account of the mining camps closing down the demand for sweet potatoes from these sources was very insignificant. Out of the 14602 pounds of sweet potatoes 9,000 pounds were sold for \$153.00. In the spring of 1908, 2,000 pounds were bedded out to pro-

pagate slips for sale. Had this large amount been sold for such purpose, the least price would have been 1½c. per pound or \$30.00. Practically 3602 pounds were not used and many of them had decayed by spring, but had they been sold earlier in the fall for one cent per pound they would have brought \$36.02.

From these figures it is seen that the estimated  
gross receipts are.....\$ 219.02  
The estimated total cost of production..... 122.28

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Estimated net receipts .....\$ 96.74

The experiment on cost of production and yield was finished in 1908. On March 10th, 1908, 500 pounds of the white Bermuda variety were bedded in a cold frame. These potatoes, which were saved from the previous year's crop, were kept all winter in a cellar-like pit at the station and consequently they did not have to be bought. Had they been bought they would probably have cost \$25.00. The middles in the young peach orchard were used for this experiment this year. On April 20th enough ridges to make an acre (30½ in number) were thrown up at a cost of \$2.90. On April 21st the potatoes were transplanted and irrigated at a cost of \$1.30. On April 21st, May 12th, June 3rd, and June 23rd, July 8th, August 3rd, and August 27th the potatoes were irrigated, the total cost for all of these irrigations being \$4.52.\* On May 27th, June 20th, and July 13th they were cultivated and hoed at a total cost of \$5.60. The potatoes were harvested on November 4th. The vines were first removed by means of the plow. The plow was run down the row and the vines were pulled off. Two men were necessary to keep the plow clean. By using the plow the cost of removing the vines was considerably reduced. The potatoes were plowed out with a two horse plow. They were cleaned and gathered as fast as plowed out. The total cost of all these operations was \$15.50. The total cost per acre was somewhat smaller than for the

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\* Two of these irrigations were given with well water.

previous year. This seems to be due to the fact that the season was more favorable. There was less well water used and the cost of irrigation was consequently reduced. The yield per acre which was 18892 pounds, was greater than for the previous year.

#### Summary of Cost of Production

|                                                  |          |
|--------------------------------------------------|----------|
| Seed potatoes .....                              | \$ 25.00 |
| Making ridges .....                              | 2.90     |
| Transplanting... ..                              | 4.30     |
| Irrigation .....                                 | 4.52     |
| Cultivation .....                                | 5.60     |
| Plowing, gathering, and cleaning .....           | 15.50    |
| Estimated cost of growing the slips .....        | 5.00     |
| Estimated cost of hauling and storing crop ..... | 30.00    |
| Estimated cost of 189 sacks .....                | 18.90    |

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Total estimated cost per acre..... \$111.72

Out of 18,892 pounds of sweet potatoes produced by the acre, 8,267 pounds of selected tubers were stored in three different sized bins in a cellar, 3,000 pounds were sold soon after harvesting them, and 7,524 pounds were placed in sand outside and covered over with the frames shown in figure 4. In this last lot were included all of the potatoes which had been bruised and cut by the plow in digging them.

Out of the potatoes stored away in the cellar, 6,778 pounds were sold during the winter and spring, and 1,489 pounds were lost from decay and evaporation. The potatoes put away outside got too hot and only 1,600 pounds were saved, which were bedded out in the spring.

The market was very "low" and poor. On the whole it was as poor as during the previous year. The 9,878 pounds sold brought \$187.08. The 1,600 pounds used for bedding purposes were worth, at least, 2c a pound or \$32.00. This would have increased the amount to \$219.08 which may be considered as the gross receipts. About 7,414 pounds were lost through decay and evaporation.



The figures show the gross receipts to be ..... \$219.08

The estimated cost of production ..... 111.75

Estimated net receipts per acre ..... \$107.33

The average estimated net receipts per acre for the three years amount to \$123.81, while the average estimated cost of production for the same time is \$128.44.

#### Keeping Test for 1908-09

| Bin   | When put away | No. of lbs. stored | With & without sand | Date examined     | No. of lbs. decayed | Total amt. decayed | No. of lbs. sound | Loss by evaporation in lbs. |
|-------|---------------|--------------------|---------------------|-------------------|---------------------|--------------------|-------------------|-----------------------------|
| No. 1 | Nov. 5        | 5417               | In sand             | 12-23             | 248                 | 248                | 4899              | 270                         |
| No. 2 | Nov. 7        | 1350               | Check               | 11-23; 12-23; 3-6 | 86; 36; 78          | 196                | 834               | 321                         |
| No. 3 | Nov. 8        | 1500               | In sand             | 12-23; 3-6        | 83; 180             | 263                | 1045              | 192                         |
|       | Total.        | 8267               | .....               | .....             | .....               | 706                | 6778              | 783                         |

From this table it is seen that there was a greater loss from bin No. 2 from decay and evaporation than from bin No. 3. The potatoes from bin No. 1 were disposed of soon after they were examined on Dec. 23rd, 1908.

#### Pruning Sweet Potato Vines

It is quite generally believed among a number of farmers that pruning the vines tends to increase the yield. In order to get some light upon this phase of potato culture the following pruning experiments were conducted during the years 1907 and 1908:

| Plat<br>1907 | Area in<br>acres | Hills pruned back<br>diameter in inches | Actual yield in<br>pounds per plat | Estimated yield<br>per acre in pounds |
|--------------|------------------|-----------------------------------------|------------------------------------|---------------------------------------|
| 1            | 1-12             | 12                                      | 377                                | 4524                                  |
| 2            | 1-10             | 24                                      | 488                                | 4880                                  |
| 3            | 1-10             | 36                                      | 759                                | 7590                                  |
| 4            | 1-10             | check                                   | 1104                               | 11040                                 |
| 1908         |                  |                                         |                                    |                                       |
| 1            | 1-125            | 12                                      | 60                                 | 7500                                  |
| 2            | 1-125            | 24                                      | 100                                | 12500                                 |
| 3            | 1-125            | 36                                      | 118                                | 14125                                 |
| 4            | 1-125            | check                                   | 176                                | 22000                                 |

From this table it seems that during both years the unpruned plants produced the heaviest yield. The plants pruned to 12 inches in diameter produced the least, while the plants pruned to 36 inches produced more than any of the pruned plants. It looks as though the more foliage the plants develop the larger will be the yield of potatoes. If pruning the vines does not increase the yield, as was the case in these experiments, then there is no object in disturbing the vines. The pruning of the vines is a tedious and expensive operation. At the Arkansas Experiment Station vines pruned showed quite a decrease in yield of marketable tubers and a corresponding increase in small tubers.\* In 1907 the plats used for the experiment were laid off between the rows in a two year old peach orchard while in 1908 the sweet potatoes were grown in a more favorable location. The season of 1907 was not as favorable as the season of 1908. On the whole the total yields for the corresponding pruned and unpruned plats were larger in 1908 than in 1907. Figure 5 shows rows pruned back to three feet in diameter.

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\* Arkansas bulletin No. 72.



Figure 5. Vines kept pruned back to 36 inches in diameter.

### Heavy Versus Light Vine Growth

In 1907 an experiment was conducted to ascertain if heavy vine growth tends to increase or decrease the yield in sweet potatoes. Two plats each 1-90 of an acre were laid off. The soil in plat No. 1 was a very good rich heavy loam, while the soil in plat No. 2 was of a light sandy character. The two plats were treated alike in every respect. There were 98 vines to each plat. The vine growth produced on plat No. 1 was very large and covered the whole surface of the plat while the vines on plat No. 2 were considerably smaller and shorter. *See Fig. 6.* On October 8th, the vines were cut off and weighed in the green stage. The tubers were dug shortly after the vines had been removed. The tubers grown in the lighter soil were more uniform in size and smoother than those grown in the heavier soil. There were a number of sweet potatoes in plat No. 1 that were considerably larger than the largest



Figure 6. Showing heavy vine growth in a peach orchard.

potatoes produced in plat No. 2, and at the same time there was a larger number of smaller tubers in plat No. 1, than in plat No. 2. Figure 7 shows the comparative size of the piles of green vines and tubers produced by the plants.

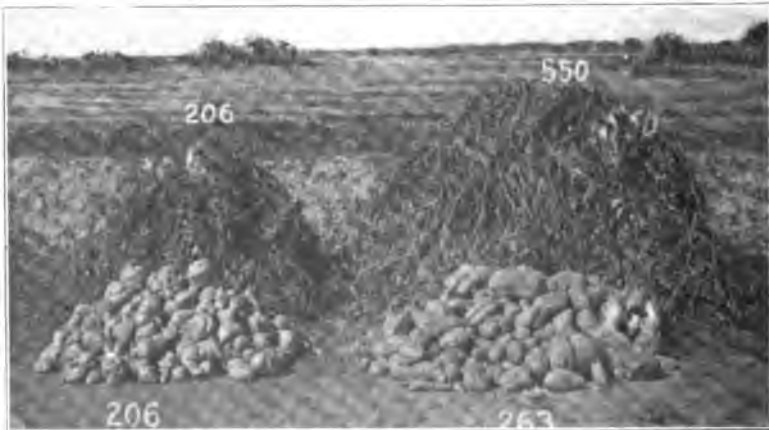


Figure 7. The smaller piles were produced in plat No. 2; the larger piles were produced in plat No. 1. The figures represent the weight in pounds.

The following table gives the weight of vines and of sweet potatoes produced by each plat:

| Plat       | Weight of green vines | Weight of tubers harvested | Difference between vines and tubers | Estimated weight per acre of vines | Estimated weight per acre of tubers |
|------------|-----------------------|----------------------------|-------------------------------------|------------------------------------|-------------------------------------|
| .....      | Lbs                   | Lbs                        | Lbs                                 | Lbs                                | Lbs.                                |
| 1          | 550                   | 263                        | 287                                 | 50,500                             | 23,670                              |
| 2          | 206                   | 206                        | 0                                   | 18,540                             | 18,540                              |
| Difference | 344                   | 57                         | .....                               | 31,960                             | 5,130                               |

From the above table it is seen that the plat producing the heaviest vine growth had the larger yield in sweet potatoes. It was noticed when the crop was being harvested that while plat No. 1 produced the largest yield the potatoes were not as uniform in size nor as smooth as those from plat No. 2. From these results one must not conclude that the heavier the soil the better the crop. It is believed that if the soil in plat No. 1 had been of an adobe character the yield would have been smaller and of an inferior quality. These figures indicate that, other conditions being equally favorable, the larger the vine growth the heavier the crop.

#### Fertilizer Test

Two experiments were conducted during 1908 on somewhat different kinds of soil with sodium nitrate. The soil in experiment No. 1 was a good average loam while that in experiment No. 2 was quite poor and sandy. The sodium nitrate was given in two applications and was broadcast on the surface along the rows. The vines from the fertilized plats made a larger growth and had a darker color than those from the check plats.

The following table gives the results of the two plats:

| Plat        | Area in<br>sq. ft. | Set<br>out | How<br>treated | Dates<br>of applica-<br>tions | Total<br>amount<br>per plat<br>in lbs. of<br>fertilizer | Esti-<br>mated<br>amount<br>per acre<br>in lbs. | Actual<br>yield<br>per<br>plat<br>in lbs. | Esti-<br>mated<br>yield per<br>acre in<br>lbs. |
|-------------|--------------------|------------|----------------|-------------------------------|---------------------------------------------------------|-------------------------------------------------|-------------------------------------------|------------------------------------------------|
| Exp. No. 1. |                    |            |                |                               |                                                         |                                                 |                                           |                                                |
| Plat 1..... | 1,330              | 4-21       | Fertilized ..  | 6-27 7-14                     | 12                                                      | 400                                             | 750                                       | 25,000                                         |
| Plat 2..... | 1,330              | 4-21       | Unfertilized   |                               |                                                         |                                                 | 590                                       | 19,666                                         |
| Exp. No. 2. |                    |            |                |                               |                                                         |                                                 |                                           |                                                |
| Plat 1..... | 1,417              | 4-21       | Fertilized...  | 6-27 7-14                     | 12½                                                     | 400                                             | 269                                       | 8,406                                          |
| Plat 2..... | 1,417              | 4-21       | Unfertilized   |                               |                                                         |                                                 | 220                                       | 6,875                                          |

While these figures cannot be taken as conclusive they show an increased yield in the fertilized plats over the check plats.

These tests further indicate, that although our soils are very fertile, the yield may be increased by the use of sodium nitrate. It is the intention to continue this work and show definitely whether or not sodium nitrate is beneficial.

#### Variety Test

During the season of 1906 a variety test of 26 varieties was conducted. The plants of 25 of these varieties were bought from Joseph W. Vestal, Little Rock, Ark. All of the Bermuda type varieties produced quite large tubers. In some cases the sweet potatoes of these varieties were almost too large for commercial purposes. The varieties belonging to the Jersey or Nansemond type potatoes seem to be preferable for commercial purposes.

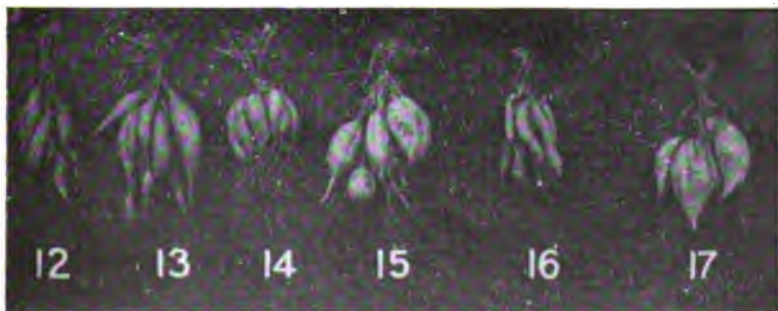


Fig. 8. 1. Ark. Beauty. 2. Polo. 3. White Bermuda. 4. Shanghai. 5. Southern Queen. 6. Georgia Yam. 7. Fullerton Yellow. 8. Florida Bunch. 9. Early Golden. 10. Gen. Grant. 11. Brazilian. 12. Red Spanish. 13. Yellow Nansemond. 14. Cooney. 15. Nancy Hall. 16. Vineland Bunch. 17. Murry's Early.

The experiments at the station have been conducted with the White and Red Bermuda potatoes. The future work with potatoes will be done with the Yellow Nansemond, Cooney, and Vineland Bunch. The experimental work with these varieties will be along the line to improve the size of the individual tubers produced by the vines. The drawback to these three varieties at present is that there are too many tubers produced on the same vine. On account of so many tubers a number of them are usually below size and are not salable. From the results of the different varieties it has been noted that the total yield per vine of the Nansemond type has been about as large as the total yield per vine from the Bermuda type. Another point that has been noted is that the skin of the Nansemond potatoes is on the whole somewhat tougher than that of the Bermuda type. This is a very important consideration in favor of the Nansemond potato. A potato that does not peel or bruise easily has the advantage over one that does. Fig. 8 shows the way the different varieties grow.

### Vitality Test

On May 16, 1906, an experiment was started to test the difference in vitality between imported and home-grown plants. The plants of the 26 varieties tested (with the exception of the Red Bermuda marked with an asterisk, which were grown from tubers bedded in a cold frame at the station), were shipped from Little Rock, Arkansas. All the plants of the different varieties were planted in rows side by side and treated alike in all respects and were fresh and healthy looking when transplanted. It became quite noticeable shortly after they were transplanted that a large number of the plants of the imported varieties were not growing while practically all of the home-grown plants were growing. During the summer a larger per cent of the imported plants died than the home-grown. The plants that lived were harvested November 13, 1906.



The following table gives the results of the test:

| Name                                       | No. of<br>plants<br>plant-<br>ed | No of<br>plants<br>har-<br>vested | No. of<br>plants<br>died | Per<br>cent<br>died | Total<br>yield in<br>lbs. | Aver-<br>age<br>yield<br>per<br>plant |
|--------------------------------------------|----------------------------------|-----------------------------------|--------------------------|---------------------|---------------------------|---------------------------------------|
| Ark. Beauty or White Nansemond .....       | 66                               | 19                                | 47                       | 71.2                | 20                        | 1.05                                  |
| Brazilian .....                            | 60                               | 13                                | 47                       | 78.3                | 38                        | 2.92                                  |
| Cooney .....                               | 74                               | 28                                | 46                       | 62.1                | 62½                       | 2.23                                  |
| Early Golden or Strasboury .....           | 60                               | 24                                | 36                       | 60.                 | 62                        | 2.58                                  |
| Early Yellow Bunch or Phillipin Yam .....  | 60                               | 11                                | 49                       | 81.6                | 11                        | 1.                                    |
| Early Yellow Nansemond .....               | 60                               | 30                                | 30                       | 50.                 | 76                        | 2.53                                  |
| Early Yellow or Pumpkin Yam .....          | 30                               | 2                                 | 58                       | 96.6                | 2                         | 1.                                    |
| Florida Bunch .....                        | 65                               | 31                                | 34                       | 52.3                | 58                        | 1.70                                  |
| Fullerton Yellow Yam .....                 | 123                              | 12                                | 111                      | 90.2                | 36½                       | 3.04                                  |
| General Grant .....                        | 90                               | 45                                | 45                       | 50.                 | 112                       | 2.48                                  |
| Gold Coin Bunch Yam .....                  | 60                               | 5                                 | 55                       | 91.6                | 2                         | .4                                    |
| Georgia Yam .....                          | 38                               | 15                                | 23                       | 60.5                | 15                        | 1.                                    |
| Murry's Extra Early .....                  | 58                               | 12                                | 46                       | 79.3                | 30                        | 2.5                                   |
| Nancy Hall .....                           | 60                               | 10                                | 50                       | 83.3                | 22½                       | 2.25                                  |
| Polo .....                                 | 57                               | 24                                | 33                       | 57.9                | 89                        | 3.70                                  |
| Purple Yam .....                           | 64                               | 19                                | 45                       | 70.3                | 32                        | 1.68                                  |
| Red Bermuda .....                          | 65                               | 20                                | 45                       | 69.2                | 52                        | 2.6                                   |
| Red Bermuda* .....                         | 225                              | 218                               | 7                        | 3.11                | 590                       | 2.7                                   |
| Red Nansemond .....                        | 70                               | 5                                 | 65                       | 92.8                | 2                         | .4                                    |
| Red Spanish .....                          | 60                               | 12                                | 48                       | 80.                 | 13                        | 1.07                                  |
| Shaoghai .....                             | 63                               | 41                                | 22                       | 34.9                | 88½                       | 2.15                                  |
| Southern Queen .....                       | 65                               | 40                                | 25                       | 38.4                | 107                       | 2.67                                  |
| Tennessee Notched Leaf or Yellow Yam ..... | 60                               | 10                                | 50                       | 83.3                | 9                         | .9                                    |
| Vineland Bunch or Yellow Nansemond .....   | 65                               | 20                                | 45                       | 69.2                | 25                        | 1.25                                  |
| White Spanish .....                        | 60                               | 13                                | 47                       | 78.3                | 17½                       | 1.32                                  |

\* These were the plants started from tubers bedded in a cold frame at the station.

It will be noticed by a study of the table that a very large per cent of the plants shipped from Arkansas died while only a very small per cent of the home-grown plants failed to grow. In a general way it has been noticed by the writer and other practical growers that plants which have been shipped a long distance are not as hardy as those grown at home. From these results may be seen the great advantage of using home-grown plants. The question will possibly arise as to why imported plants are not as strong as the home-grown plants. If we stop and consider that the sweet potato slip is nothing more than a soft wood cutting we can readily see the reason why plants which have been pulled and probably been out of the ground for four or five days should lose their vitality. The potato slip depends upon the sweet potato tuber for its nourishment. When it is pulled if not immediately transplanted, it will become weakened because it is succulent and has very little plant food stored up in its tissues. Since the potato slip has practically no food stored up in its tissues, it ought to be transplanted as soon as possible after it is removed from the propagating bed. The table also shows a marked uniformity in yield among the large growing varieties which are included in the Bermuda group.

#### **Description of Varieties**

1. **Arkansas Beauty.** Vine long, slender, petiole green, leaf deep three lobed. Tuber long, tapering, well shaped, smooth; flesh creamy, splashed with pink.
2. **Brazilian.** Vine very similar to Southern Queen with redder stem. Tuber ovate, many small undeveloped tubers; skin rough, yellowish white; flesh yellow.
3. **Cooney.** Vine very small and slim, petiole light green, leaf lobed. Tubers oblong and tapering, very yellow, smooth, small size; flesh creamy yellow. Promising variety.
4. **Early Golden.** Vine long, slim, green, leaf three lobed. Tuber oblate, rough looking, some deeply sutured; skin fairly smooth, yellowish white; flesh yellow.
5. **Florida Bunch Yam.** Vine short with a very heavy

stem, petiole long, green, leaf broad, three lobed. Tuber oblong to ovate; color very light; shape irregular, rather rough.

6. Fullerton Yellow. Vine short, thick, internodes short, stem and petiole green, leaf five cleft. Tuber oblong, yellowish white; skin smooth; flesh yellow, slightly tinged with pink.

7. General Grant. Vine very similar to Southern Queen. Tuber ovate to oblong, somewhat sutured, fairly smooth, good size and light; flesh creamy white with yellow blotches.

8. Georgia Yam. Vine thick, bushy, petiole long, leaf broad, triangular. Tuber ovate, yellowish white, somewhat rough, size variable; flesh creamy.

9. Murry's Extra Early. Vine long, thick-set, green, scant foliage, leaf narrow, indented. Tuber ovate to oblong, mostly undersized; color light yellow; skin fairly smooth.

10. Polo. Vine very similar to Florida Yam. Tuber ovate to cylindrical, some spherical, slightly ribbed; color light yellow; flesh creamy white.

11. Red Bermuda. Vine vigorous, large growing, dull red stem, long green leaf stem, leaf large, three lobed. Tuber oblong to ovate, surface rough, color red, on some the coloring is very uneven, varying from yellow to red indicating a mixed strain; flesh yellow.

12. Red Spanish. Vine scant, petiole short, internode short; leaves many and three cleft. Tuber oblong and small; color very red; skin smooth; flesh yellow, very slightly tinged with pink.

13. Shanghai. Vine long, vigorous, with purple stem, petiole green and red at base; leaf light green and five lobed. Tuber shaped practically same as Southern Queen, but not as smooth; size fair; flesh creamy.

14. Southern Queen. Vine vigorous but short growing, petiole green, leaf broad triangular. Tuber shaped ovate to round, slightly sutured, fairly smooth; color creamy white; flesh slightly lighter than skin.

15. Vineland Bunch. Vines very similar to Red Spanish;

few are bunched. Tuber oblong, tapering and smooth, small size, very yellow; flesh creamy.

16. White Bermuda. Vine vigorous, large growing, very productive. Tubers oblong to ovate, surface somewhat irregular, skin white, thin; flesh white. The potatoes grow to a large size, sometimes they are too large for commercial purposes.

17. Yellow Nansemond. Vine very similar to Red Nansemond. Tuber ovate to oblong, many undersized, skin smooth, yellow flesh, good texture. Very promising.

### SUMMARY

1. Sweet potatoes can be successfully grown in a number of places in New Mexico.

2. A rich loam is preferable to a very sandy or an adobe soil.

3. While the sweet potato plants can be planted on top, on both sides or on one side of the ridge, practically all of the potatoes grown in the Mesilla Valley are planted on the side of the ridge.

4. The plants are propagated from tubers bedded in a cold frame or hot bed, in this climate about the first of March.

5. About 500 pounds of the average commercial size tubers of the Bermuda type ought to produce enough slips from the first crop for one acre. From three to five crops of slips may be produced from the seed bed.

6. Immediately after the plants are set out they should be irrigated and from five to eight additional irrigations, depending on the season and soil, will mature a good crop.

7. The distances at which to plant the sweet potatoes vary but at this Station  $3\frac{1}{2}$  to 4 feet between the rows and from 15 to 18 inches in the row have given good results.

8. The cultivation of sweet potatoes is very simple. At this Station during the three years work, the cultivation has consisted in keeping the weeds down and plowing and drawing the dirt up to the vines two or three times during the earlier part of summer.

9. Sweet potatoes must be harvested with the utmost care. Careless handling of sweet potatoes is an important factor in increasing the loss from decay.

10. The most satisfactory results from the preliminary keeping tests at the station were obtained by putting the tubers in dry sand in a dry cellar.

11. The Bermuda type of sweet potatoes yields the most. At the station the average for three years was 18371 pounds per acre, while the average cost of production for three years, not including the hauling, the growing of the slips, and the cost of the sacks, was \$61.75 and the estimated total cost, including the hauling, slips, sacks, and care of the tubers in storage, was \$128.44.

12. According to the experiments in trimming the sweet potato vines there seems to be no advantage in this operation. On the other hand the heavier the vine growth the larger the yield of tubers.

13. Sodium nitrate used at the rate of 400 pounds per acre increased the yield of sweet potatoes in the two tests made.

14. Sweet potatoes of the Bermuda type are on the whole good yielders, but oftentimes many of them grow too large for commercial use, while the yellow Jersey varieties produce too many small tubers, but they are the best in quality.

15. According to experiments at this station a better stand in the field can be secured from home-grown plants than from plants which have been shipped from a long distance.

16. The net receipts per acre depend very largely on the yield and on the market. The larger the yield and the better the market the larger the net receipts. The estimated net receipts per acre at the station for the three years 1907-08-09 were \$123.81.

17. There is less loss from decay and evaporation when sweet potatoes are kept in dry sand.

